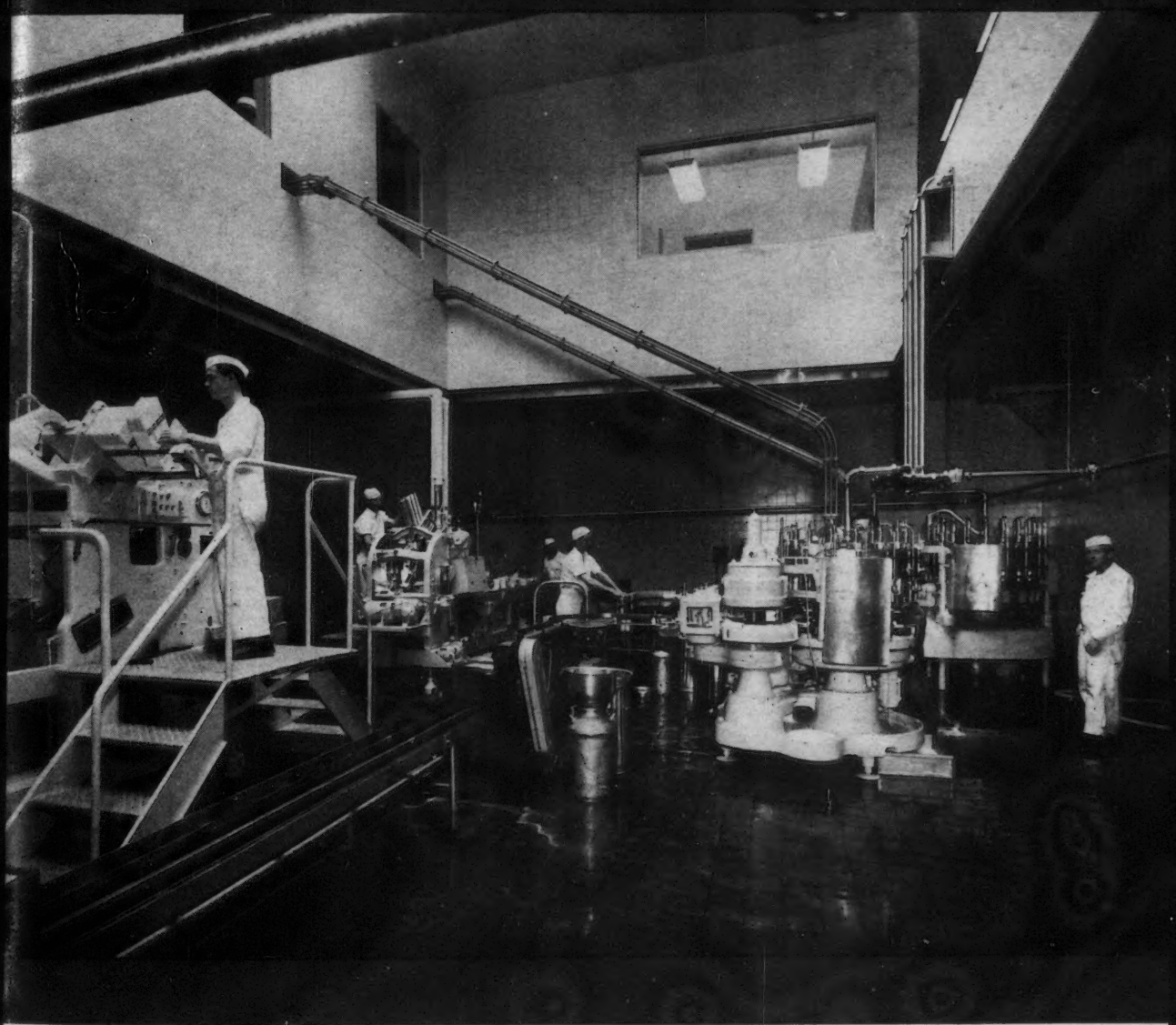
Corrosion

Official Publication of
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



VOL. 7 MARCH, 1951 No. 3

CORROSION NOW POSES A DOUBLE THREAT

Worn out and corroded equipment may not be replaceable

Don't take chances on vital equipment. Scarce metals and materials are becoming scarcer. Farsighted business men are rebuilding, repairing and *protecting* to insure continuity of their operations.

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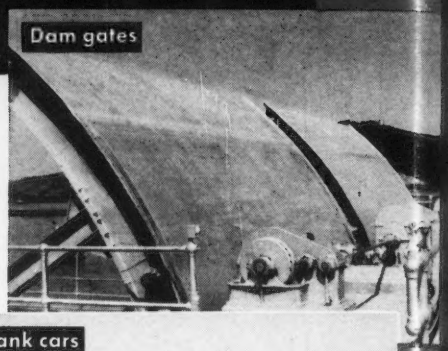

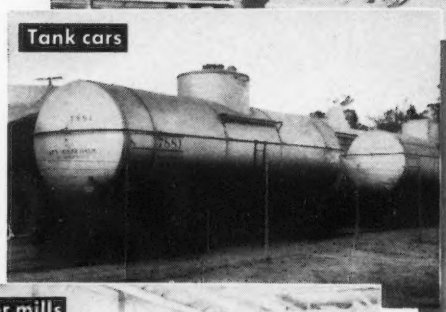

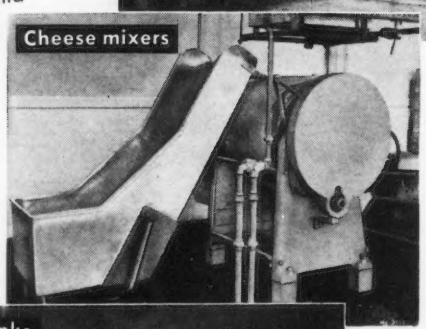

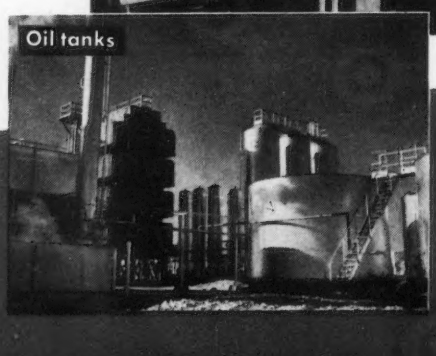

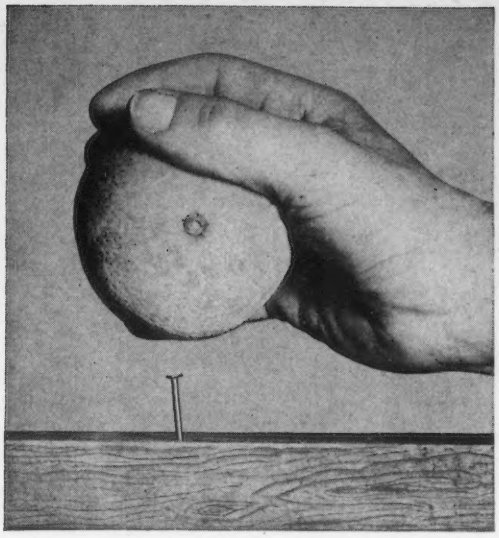

A 500-liter Dewar Flask, made of Monel®, used for transporting liquefied gases. Hofman Laboratories, Inc., of Newark, N. J., chose Monel for this service because it has the necessary strength and toughness at -330°F., and because Monel takes a mirror finish required for very high insulating vacuum.

What happens when temperatures DROP?

Many materials behave strangely at sub-zero temperatures . . . but Inco Nickel Alloys often have *improved* characteristics . . .

When the mercury freezes solid . . . and the temperature keeps on falling, common objects develop startling traits.

An orange can be used to drive a nail. A rubber ball shatters under a hammer blow. A garden hose becomes a rigid bar that will support your weight.

To the designer of low-temperature equipment, these unfamiliar antics pose serious problems. Many metals become excessively brittle . . . often to the point of being useless as structural materials. For example, an alloy steel, with a room temperature impact strength of 119.8 foot-pounds, showed a drop in impact strength to only 6.4 foot-pounds at the temperature of liquid nitrogen. Other carbon and low alloy steels show similar tendencies.

The key that has unlocked many such problems is *nickel.* Used as an alloying element in steels, nickel decreases low-temperature embrittlement.

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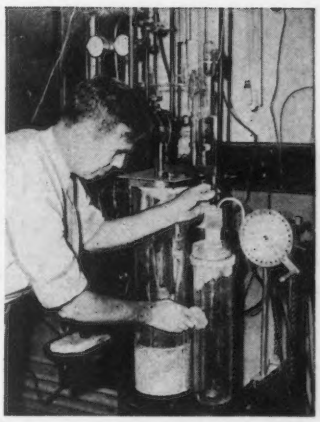
Among the many low-temperature applications, where Inco Nickel Alloys can prove highly successful, are: producing, handling and storing of liquefied gases; laboratory research, low temperature treatment of metals.

Since nickel and nickel alloys are in short supply right now, you may not be able to get all of these materials you want for your low-temperature requirements. However, for helpful advice on metal problems, feel free to consult Inco's Technical Service Section. They will be glad to help you—without cost or obligation, of course.



Helium liquefier at the National Bureau of Standards, used to study the behavior of the gas at -455.75°F. — less than 4 degrees above absolute zero. Heart of the apparatus is a thick-walled Monel chamber in which helium is cooled under pressure, preparatory to expansion and liquefaction.

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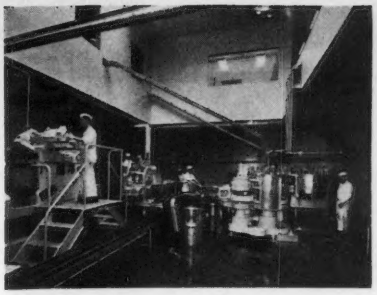

THIS MONTH'S COVER — This view of the paper container filling room of the recently completed million dollar plant of Challenge Creamery and Butter Association, Berkeley, Cal. Tile floor in this room is joined with Alkor 5E corrosion resistant cement, creating a surface highly resistant to acids, alkalis and solvents. Atlas Mineral Products Company cement was used in the installation.

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Corrosion

devoted entirely to **CORROSION** *research and control*

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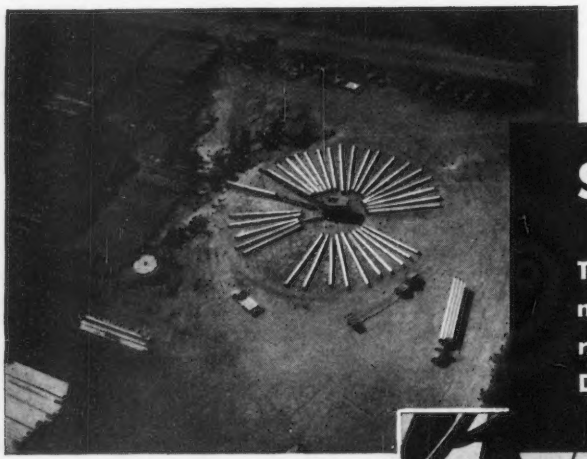

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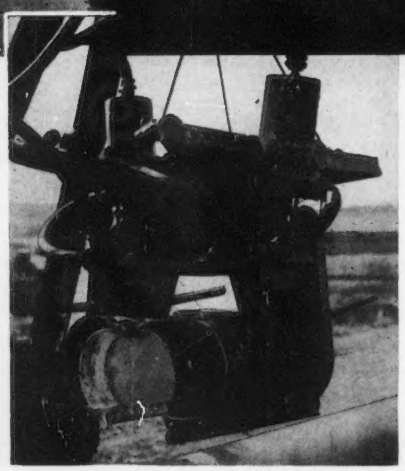

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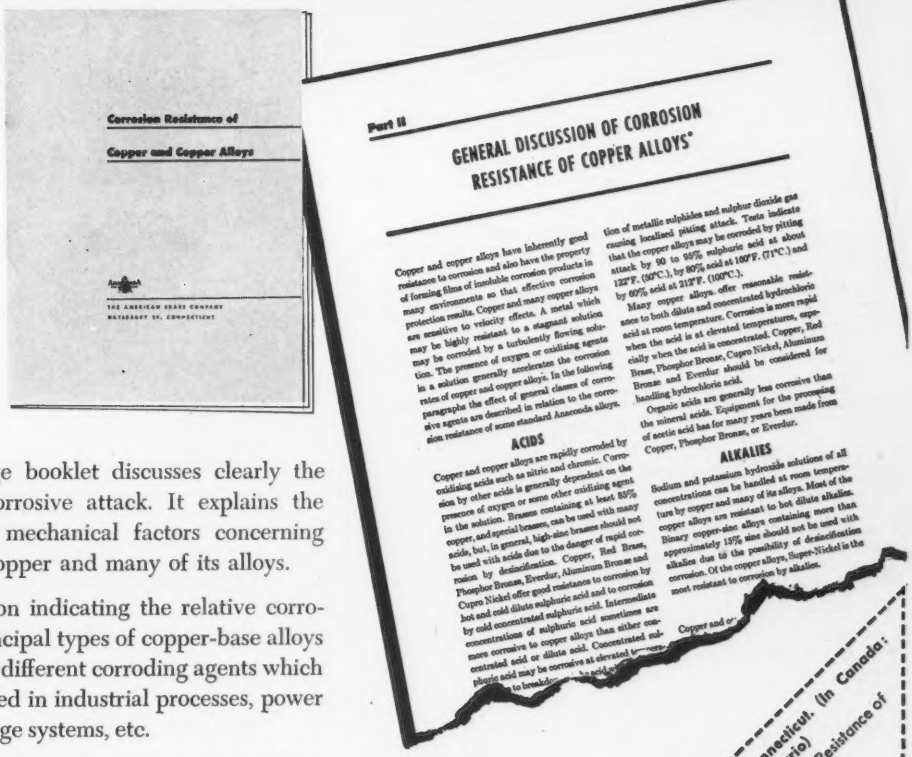

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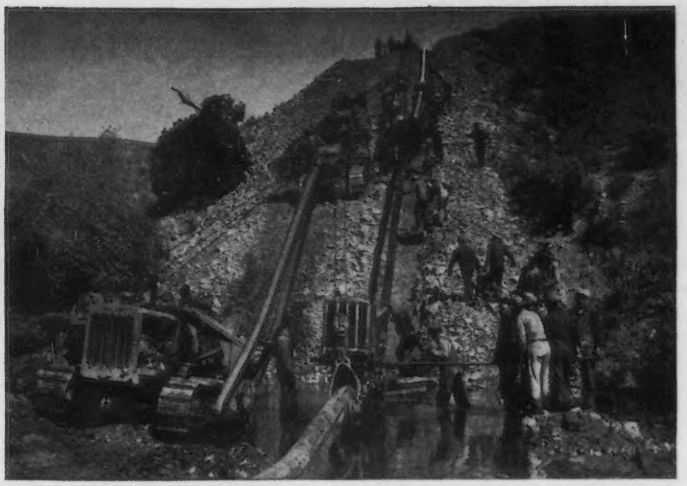
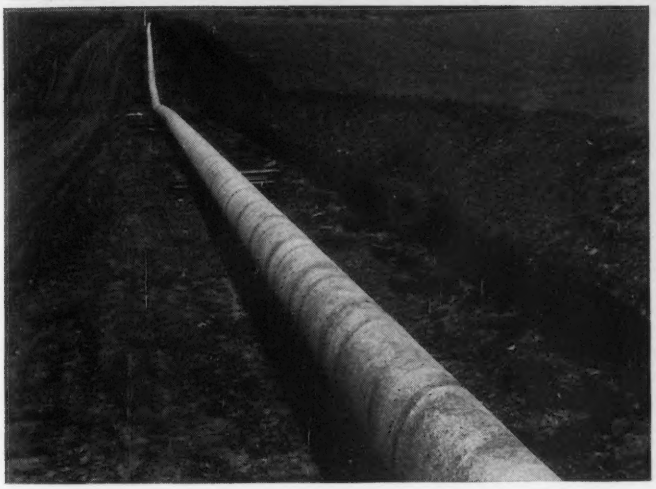

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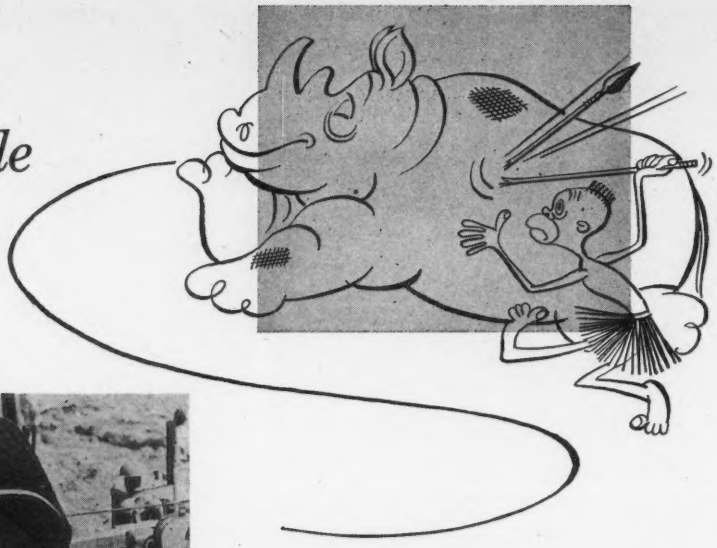

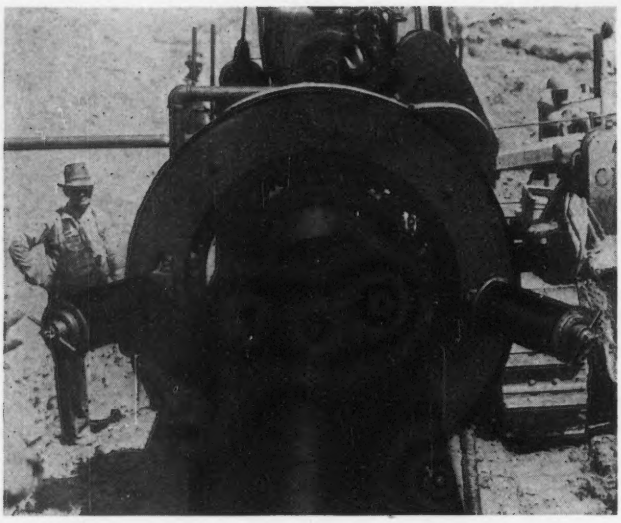

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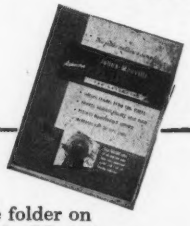

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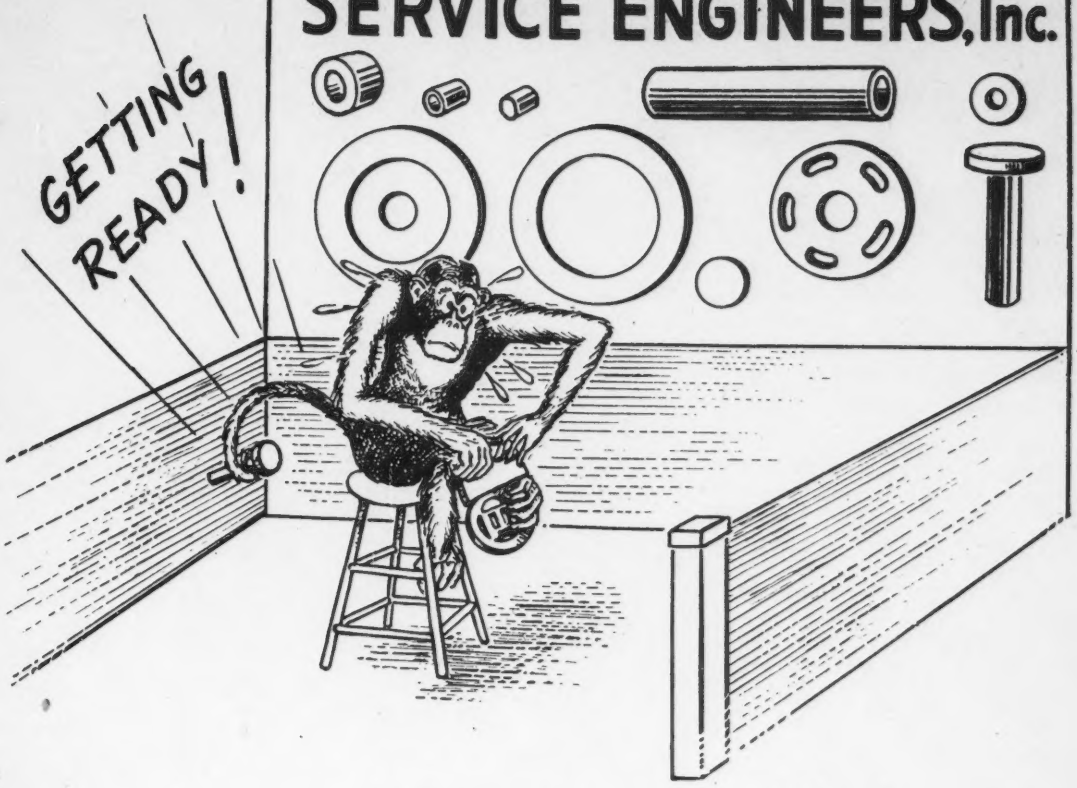

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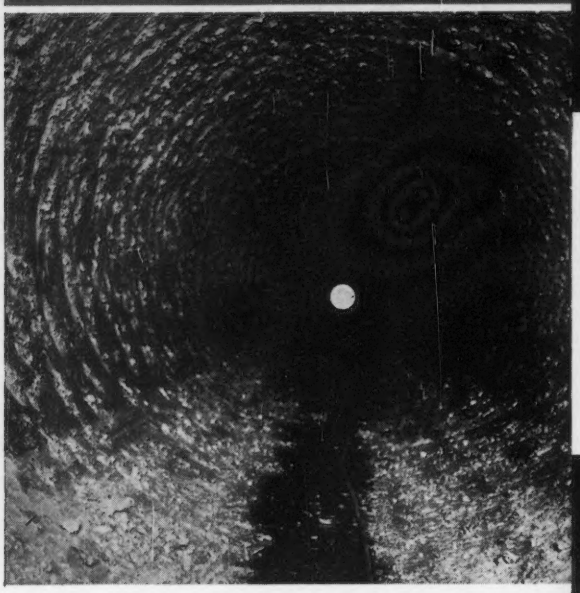

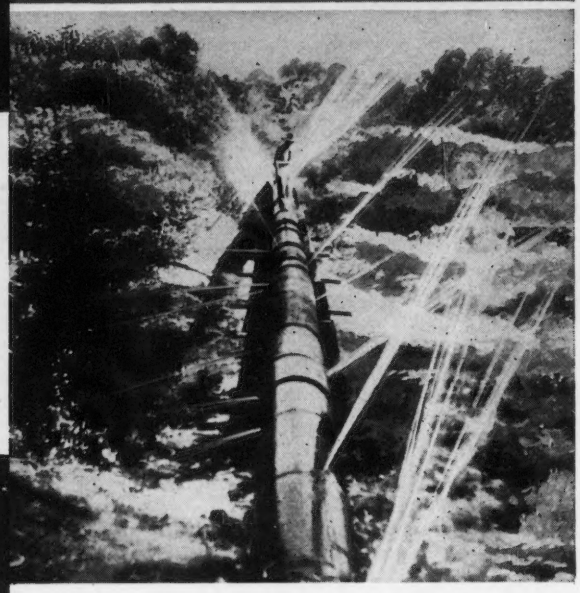

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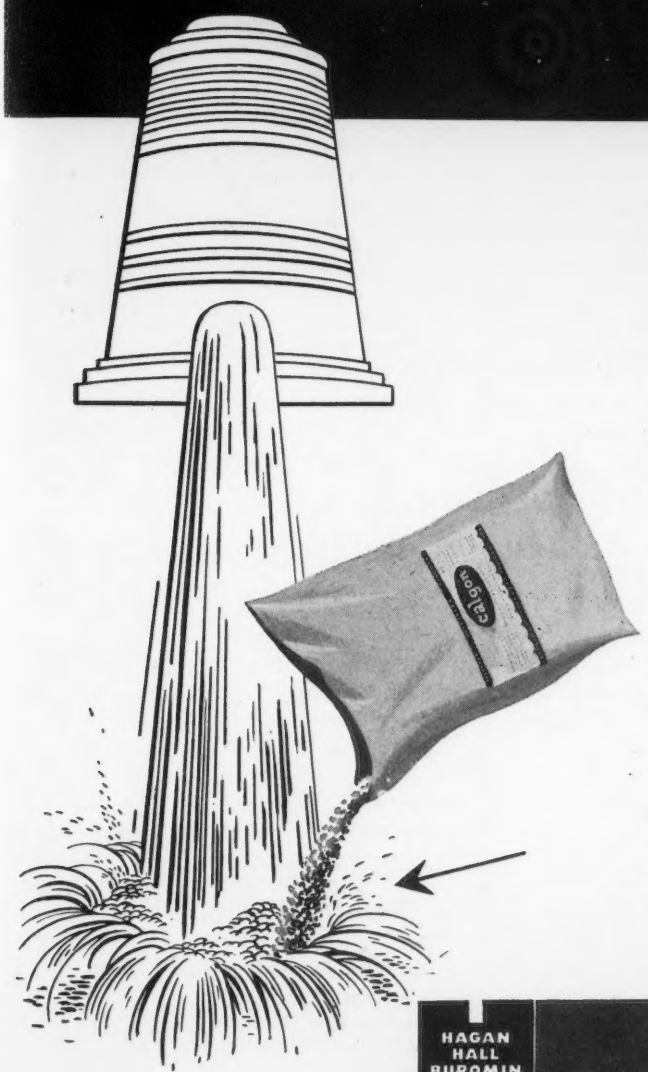

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THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 919 Milam Building, 803 Texas Avenue, Houston 2, Texas.

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Corrosion

OFFICIAL MONTHLY PUBLICATION

National Association of Corrosion Engineers

An Association of Individuals and Organizations Concerned with Control of Corrosion

919 Milam Bldg. Houston 2, Texas

Vol. 7 March, 1951 No. 3

Be an *Active* Member*

We believe it is worthwhile for every member of an organized group to take stock occasionally of himself and analyze his relation to the group. The following editorial appeared in August issue of POWER. With its permission we are passing it on to you for whatever it may be worth.

Ten Ways to Kill an Association

1. Don't come to the meetings.
2. But if you do come, come late.
3. If the weather doesn't suit you, don't think of coming.
4. If you don't attend, find fault with the work of the officers and other members.
5. Never accept an office, as it is easier to criticize than to do things.
6. Nevertheless, get sore if you are not appointed on a committee, but if you are, don't attend the committee meetings.
7. If asked by the chairman to give your opinion regarding some important matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.
8. Do nothing more than is absolutely necessary, but when other members roll up their sleeves and willingly, unselfishly use their ability to help matters along, howl that the association is run by a clique.
9. Hold back your dues as long as possible, or don't pay at all.
10. Don't bother about getting new members, let the other fellow do it.

The Editors

*Reprinted from POWER, August, 1950.

Figure 1—Roof over a coke wharf after five years' service. The corroded sheets are of plain carbon steel and the remainder are a low alloy, high-strength steel.

Corrosion Problems in The Modern By-Product Coke Plant*

By C. F. POGACAR and E. A. TICE

IT IS THE INTENTION of this presentation to discuss the use of corrosion resistant alloys in a modern by-product coke plant and to cite the results of corrosion tests in some of the processing equipment. Although the designers are continually striving to produce trouble-free plants, some compromises to corrosion must be made in view of the cost of many alloy materials. However, as replacement of old plant equipment is required, or when a unit is engineered for a new plant, full advantage should be taken of the corrosion resistance characteristics of alloy materials available.

All test data herein presented have been obtained through the installation of spool test racks in operating equipment, and consequently the results obtained are reasonably indicative of corrosion rates to be expected under the conditions of operation. It should be appreciated that all materials of construction have their limitations whether from a corrosion, fabrication or cost standpoint. Undoubtedly there might be other metals and alloys which could have been or even should have been tested, but the mechanics of testing also have their limitations.

A coke plant may be divided into three portions: the coal handling section, the ovens with their coke handling facilities, and the by-product plant. The first covers the greatest area in actual square feet as is easily visualized, the second is perhaps most important from the standpoint of having a plant at all, and the third can more accurately be characterized as a specialized chemical works.

★ A paper presented at the Sixth Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.

CHARLES F. POGACAR—Metallurgical engineer for Koppers Co., Inc., acting as technical consultant to divisions of the company on metallurgical and corrosion problems. For eight years prior to 1950 he has been a Koppers Company Fellow at Mellon Institute investigating materials of construction for coke and by-product plants. After graduation from Case Institute of Technology he first was with Westinghouse as metallurgist concerned with heat treatment of steels. He is active in technical societies and has held offices in several.

E. A. TICE—Corrosion Engineer, Corrosion Engineering Section of the Development and Research Department, The International Nickel Co., Inc., New York. Mr. Tice is a graduate of Rensselaer Polytechnic Institute, 1939, with a BS degree in chemical engineering.

The Coal Handling

The problem of continuously receiving great tonnages of coal, from 4000 tons per day in an average plant to 30,000 tons per day in the largest one, of

Abstract

This presentation covers aspects of corrosion in a modern by-product coke plant, cites results of corrosion tests in the various processing steps and describes uses of corrosion resistant alloys in some of the newer units. The corrosion data presented have been collected through the use of spool corrosion tests in plant equipment under conditions of normal plant operation. Coal-handling equipment and plant buildings suffer rather severe atmospheric corrosion. The advantages of low alloy steels for such applications, and the use of protective coatings derived from coal-tar products are mentioned. Most of the paper is devoted to a discussion of materials of construction for equipment, beginning with the evolution of the gas in the ovens and ending with its storage in gas holders. A great deal of steel and cast iron can fortunately be used for handling ammonia liquors and for gas treatment. In the ammonium sulfate "saturator" the use of both Monel and Type 316 stainless steel have shown advantages which should lead to their continued use. In the process of light-oil recovery and refining, sulfuric-acid washing and light-oil distillation offer possibilities for the use of alloy materials. Coke quenching cars require frequent maintenance and replacement. To date, economics have necessitated the use of ordinary steel for the car structure and abrasion-resisting steel for the sloping floor. Also discussed are the construction materials for primary coolers, gas exhauster, tar precipitators, ammonia stills, and dephenolizing towers.

storing it for short duration, of breaking it, in some cases washing it, and moving it into the coke ovens is primarily a mechanical one. Considerations of strength of materials, wear, impact and fatigue are of first concern. Corrosion does enter as a natural consequence of an industrial atmosphere on structural alloys. As a matter of fact, a modern plant is remarkably free of smoke inasmuch as all vapors and gases produced in a coke oven are of some commercial value.

The structural steel around the coal handling equipment is usually protected with paints normally employed for structural steel. Recent developments in the protective coating field using materials having their origin in the coke plant itself, such as refined coal tar coatings thinned with coal tar solvents, are being applied with promises of exceptional protective value. All of the conveyors are screened in, both to shield the coal and the belts from the elements as well as to keep the rest of the plant free from coal breeze. This is done with galvanized iron sheeting or as in some plants, with an asbestos filled composition board. The latter is somewhat more expensive, but in certain plants stands up longer. This is particularly true in the Pittsburgh area where the life of galvanized sheet is not as long as in less industrialized centers, as has been shown in the tests of Committee A5, ASTM.[1] However, in one plant, a section of such roofing was made of zinc and is still in excellent condition after 31 years.

Because of handling so much coal, the ground around the plants after many years becomes acidic. Thus, the steel structures at the ground level must be carefully painted and watched continuously. Because such ground is a good electrolyte, some plants also employ bituminous enamels with supplimentary

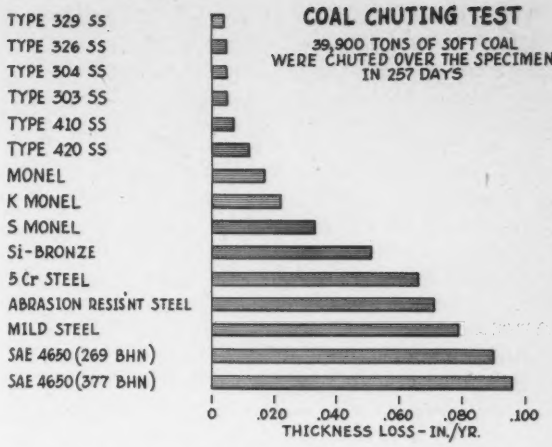

Figure 2—Results of wear test in which case the metals studied were made part of the coke chute.

cathodic protection for the underground piping. It may be of interest to note that creosoted wood is gaining application for window frames and sills and even for outdoor stairways used infrequently because of its proved resistance to industrial atmospheres.

The low-alloy, high-strength steels, which contain up to 2 or 3 percent total alloy, can be used to advantage for roofing and siding construction in the unpainted condition for applications where replacement after a reasonable life is practical. An illustration of the superior corrosion resistance of one of these steels over that of carbon steel is shown in Figure 1. This photograph shows a roof over a coke wharf where quenched coke is dumped and carried away on a conveyor belt. At the plant where this is located carbon steel sheet had given only about five years life. It was replaced with the low alloy steel but due to an error in ordering sheet material, some mild steel sheet of the same thickness was used to complete the roof. As is evident from the photograph, after five years service the mild carbon steel has corroded severely, being perforated along the bottom edge, while the low alloy steel has many years of useful life remaining. Such low-alloy, high-strength steels owe their good atmospheric corrosion resistance to the more adherent and less soluble rust layers that develop as contrasted with those forming on plain carbon steels.[2]

Coal, being a fairly abrasive material, will cause wear of chutes which have to handle large quantities of material. Ordinary steel is commonly used and is replaced when it wears out. However, chutes exposed to the atmosphere will rust when out of use for short periods, and sticking of the coal when starting up again is sometimes a nuisance. To a limited extent, both Monel and the stainless steels have come into use for coal chuting.

A test to determine the extent of abrasion by coal was conducted in a coal chute at a New Jersey plant. Comparison of the abrasion resistance of the group of materials installed in this chute is shown in Figure 2.

The Ovens

The coal charged at outdoor temperatures into the coke ovens reaches about 1800° F. during the coking period. Thus the temperature gradients not only in the coal, but throughout the ovens are complicated and ever changing. Actually, less corrosion is found around the ovens proper on metals exposed to the air than might be expected, perhaps because the temperatures are sufficiently high to keep such members dry except during a continuous downpour.

The cast iron parts of the coke oven doors, on the sides facing the ovens, are subject to minor corrosive attack as well as some high temperature scaling. Fortunately, a thick enough coating, due to condensation of tar is by itself a protective material which in turn minimizes the high temperature attack.

Most of the metal parts in contact with the oven battery are protected from the coal or hot gases by masonry, at least until temperatures below 800-900° F. are reached. Where temperatures do not fluctuate, ordinary gray cast iron is used, but where temperatures do vary an alloy cast iron containing approximately 0.25 percent chromium and 0.40 molybdenum has been found to prevent growth and ultimate fracture. Gooseneck castings from the ascension pipes which carry off the hot gases and the coal charging-hole covers and rims are typical examples of such applications.

After carbonization of the coal is completed, the doors are removed and the red hot coke is pushed, by means of the pusher-ram, through the coke guide and onto the quenching car. This car is of special construction, having a sloping floor made up of either brick or high carbon cast steel plates. The car is then moved under the quenching station where the coke is thoroughly quenched with water or, as in some plants, with waste liquor from the ammonia still (which liquor will be described below). In either case, the steam so formed coming through the quenching station chimney results in condensates which can be corrosive. The cooling medium for this quenching purpose is collected and reused and can build up its concentration in sulfates, carbonates and the like, over a period of time. The spray nozzles used are of specific design and although many alloys have been tried, most of the common materials are subject to some attack. In general, steel is used because it is most economical as an expendable material.

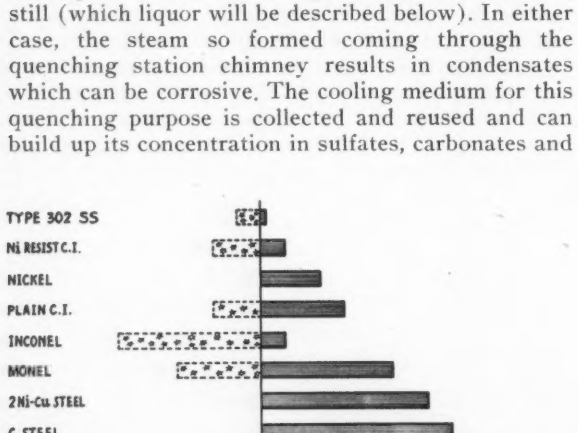

Figure 3—Corrosion rates in coke quenching tower. Corrosion rates are given as obtained from specimens suspended in a coke quenching tower below the spray nozzles. Test duration was 137 days and maximum pit depths in inches, as shown, were measured after 137 days.

Although the corrosivity of the quenching water may vary from plant to plant, the data in Figure 3 are indicative of conditions at an eastern seacoast plant employing brackish water. These data indicate that under the conditions of continuous wetting of the surfaces, small alloying additions to steel do not appear to improve corrosion resistance.

At another plant, New York City water is used for coke quenching and is recirculated to reduce water consumption. Some sulfuric acid and a considerable amount of suspended coke fines accumulate in the recirculated water. Cast iron pump impellers gave about six months' service. An "S" Monel impeller that was substituted gave about two years life. It was replaced at this time only because other parts of the pump had worn out and it was more economical to install a new pump with another "S" Monel impeller. A photograph of the two-year old impeller is shown in Figure 4. Although some corrosion is apparent it is obvious that it would still be serviceable.

After quenching, the coke is dumped onto the coke wharf where, if present, any remaining hot embers are quenched with a hose. The remainder of the coke handling equipment is similar in most respects to that for the coal at least insofar as corrosion is concerned.

Where much domestic coke is sold, some means of spraying it with a dust preventative is provided between the bins and the coke truck. Some of the spray fluids employed contain calcium chloride and when these are applied at the top of the coke chute a corrosive condition may be produced, particularly because of the added abrasive action of the coke itself. Here 18-8 stainless steel has been found satisfactory just as in the case of coal-handling equipment. Aluminum has also been used and found many times better than ordinary steel but is subject to pitting wherever coke-breeze can accumulate and stick as, for instance, at the joints between the hopper and the chute. Because of the increased pay load afforded by aluminum, truck bodies of a hardenable aluminum alloy are being used to a considerable extent for domestic deliveries.

By-Product Plant

An important product from the coke ovens, of course, is the gas. This is picked up from each oven in the so-called ascension pipes, gathered in the collecting mains and transported by pipe to the primary coolers. The gas leaves the ovens at about 700° F or higher and is cooled to 180-200° F with attendant tar condensation in the collecting main, before entering the primary coolers. Cooling of the gases is brought about by spraying ammonia liquor into it. The composition of the liquor varies between broad limits, but for present purposes it will suffice to describe it as containing about 6 to 8 grams per liter of ammonia in water with equal or lesser quantities

of carbonates and of minor quantities of sulfides, chlorides, cyanides and other salts of ammonia.

Ammonia Liquor

Large quantities of such liquor are sprayed into the gas as it flows through the collecting main. Cooling of this gas is effected by evaporation of part of the water. In addition, this serves to condense the heavy tars and to wash from the gas entrained solid and condensable materials. At the same time, this procedure results in the absorption of ammonium chloride from the gas and, by its sweeping action, keeps the mains and pipes relatively free from pitch-like deposits. These mains are normally steel. Corrosion does take place at the liquid-gas interface, but many years of service are realized before patching becomes necessary and many more years before a complete replacement is required. One plant uses stainless clad pipe in this area with the expected freedom from corrosive attack. The tars that are picked up are removed from this flushing liquor by decanting in large tanks and the separated components are subsequently collected in other suitable storage tanks. All of this equipment including pipes and pumps is also of plain carbon steel. The greatest amount of corrosion takes place in the decanting tanks at the air-liquid interface as might be expected inasmuch as the tanks are vented to the air for breather purposes. In one installation a low alloy steel is in use, but several years will be required to evaluate its performance. The decanted liquor is, of course, recirculated through the mains and eventually some of it, after further processing, may go to the quenching station.

Primary Coolers

There are two types of primary coolers used to reduce the gas temperature from the 200° F to about room temperature; the direct and indirect type. The direct type uses ammonia liquor for counter-currently scrubbing the gas in a steel tower equipped with wooden hurdles or ceramic tower packings. This action removes the remaining condensable tars and the effluent liquor is again continuously decanted, cooled and recirculated through the tower. Cast iron radiator sections or banks of steel pipe are used for this cooling of the liquor, the cooling water being sprayed over them in air. Plants along the seacoast using salt or brackish water run into corrosion problems and a continuous program of maintenance is in effect. In some cases, valves in such locations are of bronze alloys.

At one plant where the ammonia liquor is cooled by means of brackish water cascading over banks of pipe, corrosion tests in the cascading water, as well as in the ammonia liquor, were made to determine what materials might be more suitable than steel. These results are shown in Figure 5. As would be expected, alloys high in copper did not show particularly good corrosion resistance in the ammonia liquor. However, Monel, 70-30 cupro nickel, and Admiralty brass appear to have usefully low corrosion rates under the combined conditions to warrant further consideration for this cooler application. Use

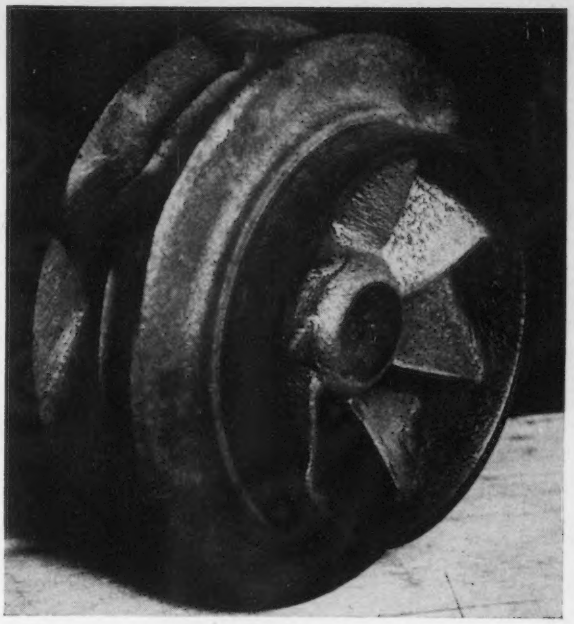

Figure 4—An "S" Monel impeller after two years' service in a pump recirculating coke quenching liquid.

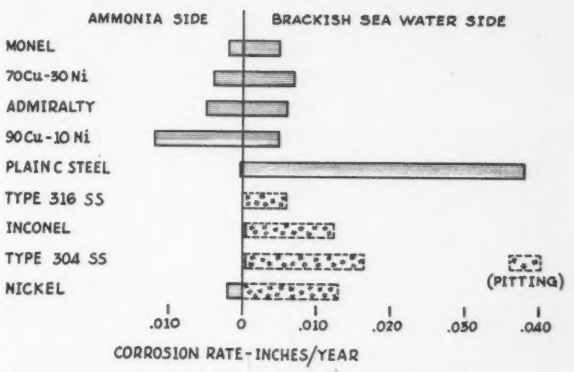

Figure 5—Corrosion rates in ammonia liquor cooler. Corrosion rates were measured on duplicate sets of specimens, one in the ammonia liquor and the other in the cooling water. Duration of the test was 63 days and maximum depth of pits resulting can be read from the scale as inches.

of Monel for the brackish water-spray pipe is indicated and at least one plant is experimenting with such metal to replace galvanized pipe which has not given satisfactory life. Initial cost of alloy materials tends to discourage the consideration of such alloys for this application; however, if four to six times the life of steel can be obtained, such materials would prove to be economical.

Several plants resort to shell and tube type of coolers in which cooling water is on the inside of the tubes and ammonia liquor on the shell side. To prevent corrosion by the water, one of the plants using river water of appreciable acid content employs bi-metallic tubes made up of copper on the water side and steel on the ammonia liquor side. At another plant which uses brackish sea water for the

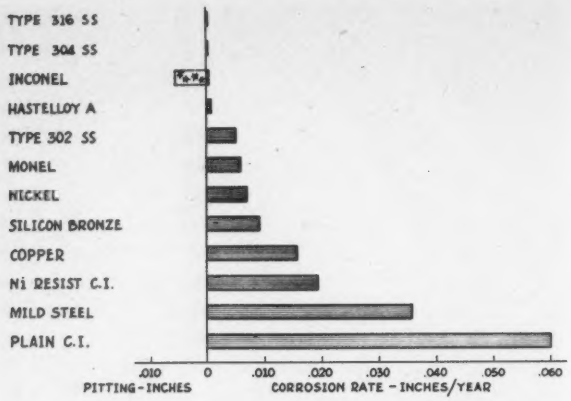

Figure 6—Corrosion rates in ammonium sulfate liquor. Corrosion rates measured on specimens located within an ammonium sulfate saturator at the "cracker" pipe after a test duration of 77 days. The temperature varied between 122 and 140 degrees F. Pitting, as shown, is maximum measured for the test period.

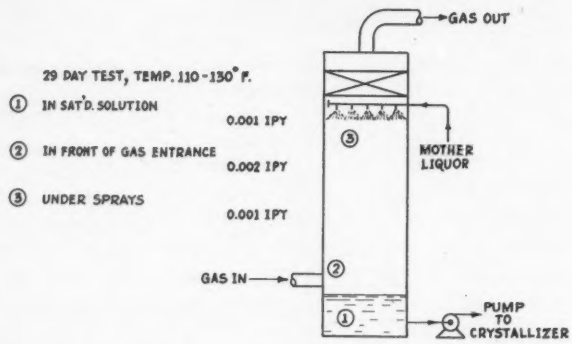

Figure 7—Corrosion rates for Monel in ammonium sulfate gas scrubber.

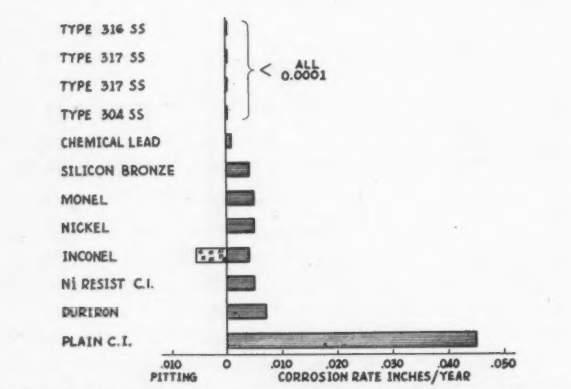

Figure 8—Corrosion rates in ammonium sulfate mother liquor mixing tank. Corrosion rates obtained from specimens after a test period of 33 days, the temperature being 100-116 degrees F. Maximum depth of pits is shown in inches for the duration of the test period.

coolant, corrosion was mitigated by the use of a Monel clad tube sheet and water box and with duplex tubes made up of steel and 80-20 cupro nickel. Here also the non-ferrous alloys were on the brackish water side and the steel on the ammonia liquor side.

The second or indirect type of primary cooler is made up of vertical tubes in a suitable tower. Water within the tubes acts as the cooling medium for the gases which are circulated around the tubes by means of proper baffles. All corrosion that does take place occurs on the water side, particularly at the open top where it is freely aerated. However, tubes frequently last for 7 to 10 years and the economics may not permit the alloys necessary for commensurate corrosion improvement.

Exhausters

The gas is pulled out of the ovens through the coolers, through subsequent stripping stages and is delivered for ultimate use, by means of exhausters which are located just beyond the primary coolers. These turbine-like machines, either steam or motor driven, are made of alloy steels consistent with such apparatus. Every plant has at least one stand-by unit for emergency use in case of breakdown. Obviously, the ovens would suffer if anything went wrong with the exhaust system. These stand-by units are usually operated intermittently for check purposes, but during their shut-down periods some corrosion may take place on the rotor or other parts within the unit. Although the parts are either of chromium-vanadium steel, or of nickel-molybdenum steel, and although there is some tar deposited on the vanes and acts as a protective coat, enough does flow off to permit attack, if air is allowed to leak into the unit. This attack by itself is not serious, but the resulting unbalance, slight as it may be, can be sufficient to cause appreciable trouble by way of vibration and subsequent bearing difficulties. Such corrosive attack has been overcome in one plant by bleeding coke-oven gas into the exhauster to maintain a slight positive pressure when standing idle.

Tar Precipitators

The gas discharges from the exhausters into the tar precipitators where at least 90 percent of the remaining tar in suspension is removed from the gas by electrical precipitation. One type of precipitator is made up of vertical tubes of thin steel sheet about 8 inches in diameter suspended from a suitable tube-sheet. Through the center of each tube is a twisted square rod insulated from the tubes from which a corona discharge is produced.

In another type of precipitator the rods are spaced between cylindrical plates. The particles of tar are thus electrostatically separated from the gas flowing upward through the electrode assembly located within the precipitator. If the temperature of the gas is above the dew point of its moisture content and if the oxygen content is low there is no corrosion problem in these precipitators. However, if the cited conditions do exist the tubes or electrode assembly will corrode. Some oxygen in the gas is inevitable but if corrosion is suddenly found in unexpected places, one of the first checks is to determine its amount for a possible corrosion clue.

Sulfate Saturators

The ammonia in the weak liquors is liberated by steam distillation. The liberated ammonia is then

added to the main gas stream ahead of the ammonia absorption step. The total ammonia is removed from the gas by means of a solution of sulfuric acid to form crystalline ammonium sulfate in the great majority of plants in the United States. Until recent years this removal was accomplished in saturators. However, the development of suitable alloys for pumps, spray nozzles, etc., to withstand the corrosive action of sulfuric acid solutions under coke plant conditions has permitted the design of spray-type equipment for this purpose.

In the saturator, the gas is bubbled through a 5-7 percent sulfuric acid solution and the crystals of ammonium sulfate so formed are suspended in the sulfuric-acid liquor. The resultant slurry is continuously pumped off and the crystals are separated by centrifuging, then dried and stored for shipping. There are many modifications of the saturators, but all have to be designed to resist the sulfuric acid attack. The older units are made of steel shells and totally lead lined. The violent turbulence of the liquor, resulting in an erosive action by the crystals, causes considerable wear of the lead at vulnerable spots. One such spot is the "cracker pipe" which dips into the liquor to introduce the gas. Although dilute sulfuric acid normally produces insoluble lead sulfate on the surface of the lead, the wearing action is sufficient to demand periodic maintenance of the lead lining.

Within the last eight years, as mentioned above, the use of alloys other than lead for saturator equipment has been a major development. Both Monel and Type 316 stainless steel are being used with success from the standpoint of corrosion and erosion resistance. When using Type 316 stainless steel for saturator construction, it is esseential that all welded parts that cannot be subsequently annealed, be made of low carbon material, in order to preclude the possibility of accelerated attack in the heat affected zone adjacent to welds. Obviously the use of these two alloys for the corrosive conditions prevailing has enabled improvements in design not permissible with lead lined equipment. Such changes have effected a considerable savings in power required to pump the gas through the by-product plant.

Comparative results of corrosion tests made in operating units under identical operating conditions, are shown in Figures 6, 7 and 8. The results for Type 316 stainless steel in Figures 6 and 8 have been duplicated on numerous installations where even machine marks are visible after many years of exposure to the acid mother liquor. Inspection of the Monel equipment in one of the low differential type saturators, after 1½ years of use, has indicated that actual prevailing corrosion rates for Monel are less than that shown in these figures.

Operating experience to date has indicated that both materials may be expected to give long useful life, providing the precaution mentioned above in regard to Type 316 stainless steel, is adhered to. A photograph of a Monel low differential cracker type saturator is shown in Figure 9. Figure 10 shows a Type 316 stainless cross-flow spray type absorber in which large sized crystalline ammonium sulfate is produced.

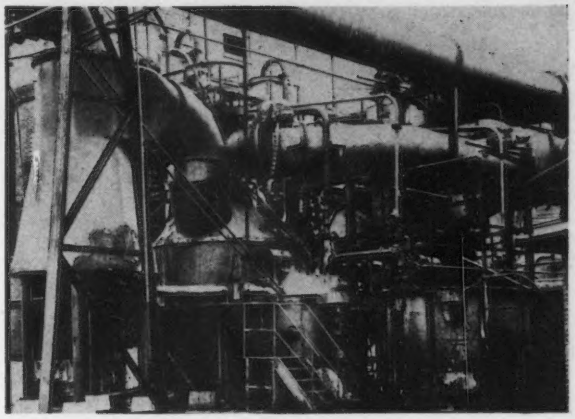

Figure 9—The Monel low differential cracker pipe type saturator is shown in the foreground.

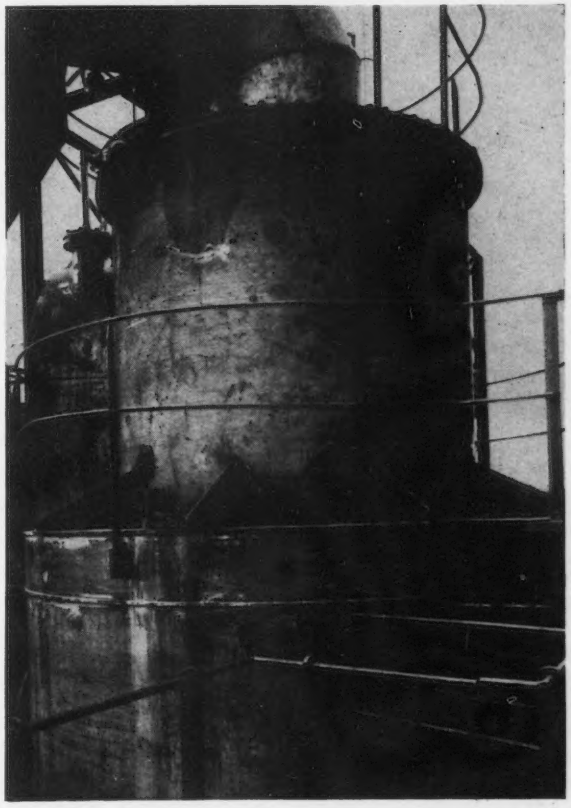

Figure 10—Upper portion of a Type 316 stainless cross-flow spray type absorber.

The concentrated acid used for making up the liquor is stored in steel tanks. It is then either introduced directly into the saturator or is premixed with the mother liquor after it comes off the centrifuges. This latter practice would be done in lead, Type 316 stainless or Monel. In any case the process of diluting the acid while it is in direct contact with the alloy or metal must be avoided.

The gas coming from the saturator goes through an acid separator usually of the two-cylinder type wherein the gas is forced to change direction by 180°

and the entrapped acid solution is mechanically separated. Such separators are also made of the same metals as used for the saturators. The gas then leaves such equipment in steel mains for further processing.

The pumps, valves, centrifuge baskets and piping handling the sulfate slurry and mother liquor are made of Type 316 stainless, Monel or acid resisting bronze. The sulfate crystals are washed with water while they are in the centrifuge baskets and then dried and piled for loading. Metal conveyor systems leading to railroad cars usually are of ordinary steel.

Materials for centrifuge construction are worth mentioning. In the past bronze baskets have been commonly used. More recently Monel and stainless steel have come into use, not only for the baskets, but for the housing of the unit. At one plant which employed two centrifuges in parallel, four bronze baskets were used over a three year period. These were then replaced with three Monel baskets, and after five years these baskets were still in service. The slotted screen in the centrifuge basket was a maintenance problem until Type 316 stainless came into use. Today it is the preferred material, although Monel screens are still used to some extent.

Another method of separating the crystals from the slurry is by vacuum filtration. It has been found that Monel metal is satisfactory for the filter body, but Type 316 stainless steel is preferred for the fine filter screen cloth. Although the latter is somewhat more expensive than Monel screen, its longer life justifies its use.

The gas coming from the saturator and acid separator goes through a final cooler constructed similarly to the direct-type primary coolers except that water is always used for the cooling medium. The circulating water itself is cooled in wooden towers designed for such purposes.

The gas is then introduced into the bottom of the light oil scrubber where it is scrubbed with so-called wash oil to remove the light oil. The wash oil, a petroleum derivative, is sprayed in the top of the steel tower over wooden hurdles or steel turnings and absorbs from the gas the benzene, toluene and xylene, and in minor quantities other substances making up the light oil.

Following the washing of the light oil from the gas, the gas is given a final purification treatment for the removal of hydrogen sulfide after which it is ready for distribution or storage. The gas holder serves its ordinary function and, as usual, its wide expanse of steel is painted for protection from the elements.

Ammonia Still

Referring again to the ammonia liquor after having left it earlier in the storage tank following decantation of the tar, it is then treated in an ammonia still. The ammonia liquor enters at the top of the still, which is usually a bell and tray type of column, wherein it is stripped by steam of its free ammonia. The ammonium compounds which readily dissociate such as the carbonate, bicarbonate, sulfide, etc., are volatilized at this point. This liberation is done in the top half of the still. The stripped liquor containing only the fixed ammonia, so called because of the firmer bonds with chlorides, sulfates, and others, is then mixed with a lime-water solution and allowed to continue down through the bottom half of the still. The reactions with the lime permit the release of the combined ammonia and by further aid of steam the liquor is totally stripped. The still is entirely constructed of cast iron usually containing small amounts of nickel and chromium. Some corrosion does take place, but the rate is so low that maintenance due to corrosion is no problem. The steam and ammonia vapors leave the still to enter a dephlegmator where the steam is condensed and the ammonia vapors are allowed to pass through. The latter are then piped back into the gas main somewhere upstream from the sulfate saturators for final recovery. Where dephlegmators are used, they are generally made of aluminum alloys because of satisfactory corrosion resistance. Such corrosion as is experienced is predominantly from the water side. Two plants have been successful in extending the metal life by cathodic protection with zinc. Figure 11 shows one such installation wherein zinc blocks were located in the water boxes.

Dephenolizing Tower

The ammonia liquor is actually drawn off at the middle of the ammonia still, after the free ammonia has been liberated, but before it is mixed with the lime, and piped to the dephenolizing tower for removal of the phenols. The liquor is here countercurrently scrubbed with steam and hot vapors which carry off the phenols. These vapors are in turn scrubbed by a caustic soda solution resulting in the formation of sodium phenolate. (This latter compound is usually shipped elsewhere for springing of the phenols.) The dephenolized liquor, on the other hand, is returned to the "fixed still" portion of the ammonia still for completion of the cycle as described in the paragraph above. If the dephenolizing tower is carefully stress relieved it can be constructed of plain carbon steel. Under any other conditions, failures by stress corrosion cracking are possible because of the hot caustic solutions. In one case, such failures started, and repeated repairs by welding only made matters worse until it was obvious that a new bottom would have to be installed. In this case, because of construction limitations the reboiler section was built as a separate unit, properly stress relieved, with complete operating success. Corrosion data in the feed to an ammonia still and in the liquor from the middle of the still leading to a dephenolizing tower are given in Table I.

Light Oil Plants

The light oil recovered from the gas, by means of the wash oil absorption, consists mainly of benzene, toluene and xylene. These constituents by themselves are not corrosive to steel equipment, but the chemicals used to purify them create corrosive conditions which may necessitate the use of corrosion resistant alloys.

The light oil, after being distilled from the wash

TABLE I

Corrosion Tests in Ammonia Distillation Process

Test 1: In ammonia liquor feed to the still. Temp. 100° F. Test duration, 449 days.

Test 2: In ammonia liquor from middle of still, near lime leg, which is fed to dephenolizing tower. Temp. 215° F. Duration of test 307 days.

MATERIAL	CORROSION RATE			
	TEST 1		TEST 2	
	IPY	Max. Pitting During Test, Inches	IPY	Max. Pitting During Test, Inches
Type 316 SS	.....	....	0.0002	None
304	<0.0001	None	0.0002	0.014
302	<0.0001	None	0.0002	None
Inconel	<0.0001	None	0.0001	None
Monel	0.0002	None	0.0006	0.004
Nickel	0.0002	None	0.0006	0.003
Copper	0.008	0.016*	....	....
Admiralty Metal	0.002	0.016	....	....
Aluminum 2S	0.001	0.012	....	....
Lead	<0.0001	None	....	....
Mild Steel	<0.0001	0.009	0.002	0.006
5 Percent Ni Steel	<0.0001	None	0.001	0.008
Low Alloy Steel	<0.0001	0.005	0.002	0.012
Ni Resist, I	<0.0001	None	0.0006	None
Cast Iron	<0.0001	None	0.003	None

* Perforated. < Less than.

oil, is treated with sulfuric acid to remove undesirable constituents. This operation is conducted in a cone bottom washer equipped with an agitator. Concentrated sulfuric acid is employed for washing, and in many cases the acid is added in a series of operations. This may or may not be followed by water washing. In either event the last step is a caustic neutralization.

In plants where no water wash is employed, steel and cast iron equipment, which adequately resist concentrated acid, have been found to give economical life. However, in plants where water washes are employed, steel is not satisfactory for the dilute acid so formed, and the use of alloys is required. Lead lined steel has been the most common material for such light-oil washers and Monel or acid resisting bronze has been used for the agitators, shafts, and valves.

Results of corrosion tests in light oil washing, with and without water washes, are shown in Figures 12 and 13. It will be noted that the use of a water wash greatly alters the corrosion problem.

Conclusion

This paper, of course, has not covered all processes and types of equipment existing in all coke plants. In considering corrosion problems and the use of alloy materials for any chemical process equipment, it must be realized that no two plants are necessarily alike. Corrosive conditions in a process may vary from plant to plant because of slight variations in operating procedures. Therefore, when confronted with a corrosion problem, it is advisable to conduct appropriate tests in the plant equipment involved. Nevertheless, it was the intention of the authors to present data as obtained from specific units which data may serve as a guide for the future selection of materials of construction for similar equipment.

Acknowledgment

The authors wish to express their appreciation to Mr. W. Z. Friend of the International Nickel Com-

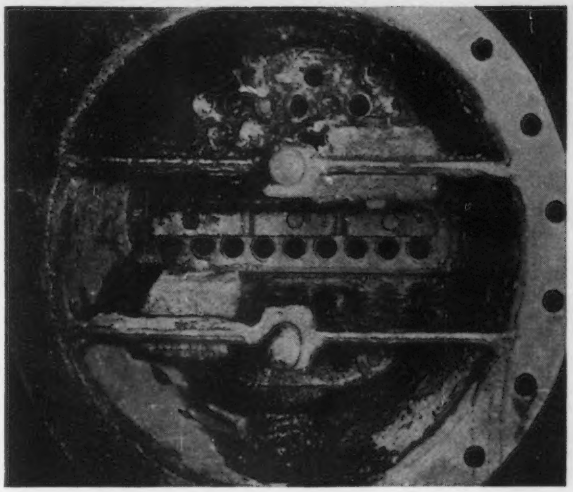

Figure 11—Water box of an aluminum ammonia still dephlegmator showing zinc blocks fastened to water baffles for cathodic protection.

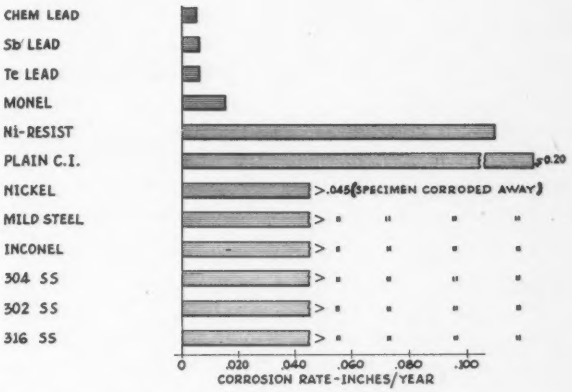

Figure 12—Corrosion rates in crude benzol washer wherein a water dilution follows the acid wash. Corrosion rates as measured on specimens after a test of 124 days.

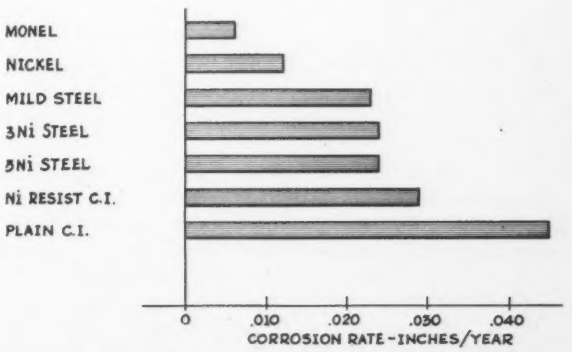

Figure 13—Corrosion rates in crude benzol washer wherein NaOH neutralization follows directly the acid wash. Rates measured on specimens after a test of 145 days. (Compare with Figure 12 which gives results for different washing technique.)

pany, Inc., and to Mssrs. E. V. Schulte and E. W. Volkmann of Koppers Company, Inc., for their suggestions and helpful criticisms during the preparation of the paper.

References

1. *Proceedings of ASTM*, **48**, 108-113 (1948) Report of Committee A5 Sub XIV.
2. H. R. Copson, "A Theory of the Mechanism of Rusting of Low Alloy Steels in the Atmosphere," *Proceedings of ASTM*, **45**, 554-590 (1945).

(Further comments by E. A. Tice on this topic will appear in April, 1951 Corrosion).

DISCUSSION

Questions by Mars Fontana, Ohio State University, Columbus, Ohio:

1. Please give the composition of the roofing sheet that shows good performance as indicated by the photograph.

2. Was extra low carbon Type 316 stainless steel used for fabrication of the vessels?

Reply to No. 1 by E. A. Tice:

The roofing sheet steel was of the following chemical composition range:

Carbon	0.12% max.	Silicon	0.10-0.50
Manganese	0.50-1.00	Chromium	0.40-1.00
Phosphorus	0.08-0.12	Nickel	0.25-0.75
Sulfur	0.05 max.	Copper	0.50-0.70

Reply to No. 2 by C. F. Pogacar:

The so-called extra low carbon (ELC) stainlesses contain 0.03% carbon maximum. The steels used in fabricating the stainless saturators, however, were purchased to specifications calling for 0.06% carbon maximum. We have found by experiment that such analysis is entirely satisfactory for sulfuric acid applications such as saturators, without the usual high temperature annealing heat treatments after welding. Undoubtedly some carbides are precipitated during the welding procedures but not to the point where corrosion would be a problem. That is not to say, however, that an 0.06% carbon material would be satisfactory for all chemical applications without annealing if welding fabrication is used.

What Management Expects From the Corrosion Engineer*

By JOHN J. JACOB, JR.

THE REAL ANSWER to this question is—"A whale of a lot." However, in attempting to analyze this subject I found myself confronted with another question, namely, "Does management know what to expect from a corrosion engineer?" Right here is where I would like to open my remarks by saying that first the corrosion engineer has a terrific job of selling himself and his profession to management.

Almost every company has an expensive physical plant. It has machines and equipment to convert a raw material into a salable product, buildings to house that equipment, and pipe to get utilities into the property and waste products out. The plant is exposed to the elements—air, moisture, and soil—and to any number of corrosive agents unique to the materials handled in the plant.

As our company is engaged in the production, transmission and distribution of natural gas, my remarks will apply more particularly to pipe lines as connected with the public utility business. We have pipe in wells, in cross-country transmission lines, and in city streets. We have compressor stations, measuring stations, warehouses and offices. For years, in fact from the beginning, we have had specially trained men looking after each step in getting gas from the ground to the consumer. It has only been in recent years, say the last fifteen, that we have assigned to any one man the task of protecting our plant against corrosion.

I think we will have to admit that the corrosion engineer is more or less a new member in our company organization and it is rather difficult for some managements to appreciate his value because we are

JOHN J. JACOB, JR., was born in West Liberty, Ohio County, West Virginia. After graduation from West Virginia State Teachers College he entered the University of West Virginia and was graduated from the School of Civil Engineering with a Bachelor of Science degree.

Mr. Jacob was first employed in the engineering department of the Consolidation Coal Company at Fairmont, West Virginia. He later joined the Baltimore and Ohio Railroad Company, serving first in the geological and later in the valuation department. Since 1922 Mr. Jacob has been connected with The Peoples Natural Gas Company and the New York State Natural Gas Corporation in various capacities with the engineering and operating department. In 1942 he was made vice president and assistant manager in charge of operations for both companies and is still serving in this capacity at the present time.

★ Presented at the fall meeting of the Pittsburgh Section, National Association of Corrosion Engineers, October 19, 1950.

EDITOR'S NOTE: This paper has been approved for publication in the technical section of Corrosion because it will help promote understanding between engineers and management and in the end may intensify efforts in controlling corrosion.

all prone to judge the future by the past, and since we have been in business for many years without the services of a corrosion engineer we are apt to say, "Why do we need him now?" Anyone who reasons this way is forgetful that many things have changed during these last few years, things which have had a tendency to create a need for a corrosion engineer—a need which did not exist in olden days.

Regarding the matter of more things to consider —by this I mean there is more steel used each year than the previous year, and due to more coal being mined each year and more industrial plants in operation there is an increased tendency to stream pollution which in turn contaminates the soil in the immediate vicinities. The dumping of slag and waste from the coal mines as well creates a new hazard in the contamination of the soil in the vicinity of these dumps. It is also true that in certain industrial areas the air is more contaminated from fumes than in the years past, thus creating another additional hazard.

So may I repeat—the corrosion engineer has a huge selling job on his hands. But the corrosion engineer may say to me, "How can I sell myself to management if I do not have an entree?" I will have to admit that I do not have the answer to that one myself except to say that you should be ready if the chance presents itself. Personally, I am unsuited to offer that kind of advice because doubtless I am the world's worst salesman, but at the same time, I am quite gullible to the proper type of salesmanship.

I will confess that I was indifferent to the idea of corrosion prevention until a simple gadget which sat on my desk for about ten days changed my attitude. One of our engineers suspended small steel panels in glass beakers and connected these to a hot-shot battery. One beaker contained distilled water and the other river water taken from the Monongahela River near Monongahela City. In each beaker were two panels, one coated and one bare, and a platinum wire. A hole was made in the coating of each panel with a pencil point. At the end of ten days the coated panel in the river water had a hole almost through the panel, and the uncoated sample was etched with a leafy appearance. Those samples in distilled water were still bright after ten days. There were meters to show me what was happening but the real proof was the panels. In fact I still keep those panels in my desk and here they are if you want to see them. This was a very simple experiment but it was very effective in selling me the idea that there was something to our corrosion problem and that I should become interested in doing something about it.

Natural gas itself is not corrosive but the exterior of our pipe is exposed to very severe conditions—damp industrial atmospheres above ground and coal outcrops, cinders, red dog, slate and slag fills, mine drainage, as well as domestic and industrial wastes below ground. Corrosion costs us money but we are fighting it.

No one expects the plant to last forever, and it is usually not economical to try to make it do so, for processes become outmoded, units too small, and conditions and buyer demands change. However, there is a point where money spent to prevent corrosion will pay big dividends.

Wear can be minimized but cannot be prevented, and parts will have to be repaired and replaced. Corrosion can be prevented, and only when preventative measures are more expensive than replacement can its neglect be justified.

In some cases it is difficult to get management to take time to really consider the matter seriously. For example, I have recently been approached by the district manager of a large corporation with the request that I loan him the services of a corrosion engineer to study a particular problem of his and to give him some advice relative to his need for cathodic protection. After due consideration and consultation with one of our corrosion engineers, I had our engineer call on this gentleman to see what his problem was. Without going into further details I can tell you that this gentleman wanted a particular part of his plant inspected and wanted our corrosion engineer to give him a report on suggested things he should do to prevent further corrosion on this part of his plant. It also developed through this contact that here was a sizable corporation whose management had never been sold on the idea of employing a corrosion engineer. This district manager in some way realized that he had a problem and also knew that he had no way of coping with the problem through his own organization because his top management had never been sold on the idea or the necessity of providing in their financial budget any moneys to employ a corrosion engineer. Now I believe, without having any statistics to definitely refer to, that there are many other corporations in this part of the country which are in exactly a similar situation. There may be somebody else down the line of management who thinks there should be something done about this matter but he either is not sufficiently convinced of it himself or does not have time to get into the matter to push it to the top and endeavor to do something about it.

Again, I do not know that the corrosion engineer can do any good in a case like this until he is invited to discuss the matter with management. I believe this invitation will come, sooner or later, and when it does come then that is the time when the corrosion engineer should be ready to sell himself and his profession to management.

Now getting back more directly to the subject, management is always interested, or at least should be, in the economics of its business because it is management's duty to the stockholders of the company it represents to operate that business as economically as possible and the value of a corrosion engineer is directly proportional to his ability to save the company money by preventing or retarding corrosion as much as possible within certain economic limits. Right here is where management needs a well-qualified corrosion engineer. I am not going to attempt to give all the qualifications of a corrosion engineer but there is one I would like to mention and especially emphasize.

First and last the engineer should be not only a

well educated and trained employee but also, and above all, he should be a diplomat; in other words, a liaison man between the operating department and the management. His primary function is of an advisory nature. I believe that many a young man in this profession, as well as in other professions, has made the mistake of trying to impress the operating foreman with his superior education and training and has thus antagonized the very people on whom he must depend in order to make his work a success. Not only has he done himself a personal injury by his attitude but he has also done an injury to his profession.

Now since I have suggested that the corrosion engineer is to be a liaison man between operations and management, I think it only fitting to suggest a few things management should do to make his job easier. First, management should acquaint the various departments of that company with the fact that there is a man in the organization who is working with the full approval of management to cut down costs of repairs and replacements caused by corrosion. Every outfit has its old-timers who are resistant to change and resent having some newly employed college graduate tell them they have to change something they have been doing for thirty years.

The happiest solution to this problem is to choose as the corrosion engineer a man who can and will get along with others. An engineer who can sell himself and his job to the operating personnel by convincing them that he is saving them time and trouble will get cooperation. However, management must assure these operating men that their views will also be heard.

Management should not expect the engineer to make decisions or determine policy. He should make full reports to management with his recommendations and, if possible, alternate methods. These reports should include costs now, probable life, cost of maintenance, availability of materials, ease of installation and service, and reasons for recommendations. To get these figures, the engineer must depend upon someone in the purchasing or accounting departments.

It is not expected that the corrosion engineer be an expert on costs, bookkeeping and accounting. There are men in every company to furnish the engineer with the information he will need. Management must determine what figures are to be made available to the engineer and make this known to the various departments concerned.

Management should encourage the corrosion engineer by arranging an occasional informal meeting for him with officers and department heads where a give-and-take question and answer session can be of great help to all parties. The engineer does not have the experience, or the bird's-eye view of the business that is enjoyed by management. These conferences will give the engineer a chance to present his ideas and will keep management informed on his plans and problems. It can thus give direction to his program.

Timing of demands upon the corrosion engineer can be all important. Management should see that the corrosion engineer gets in on the ground floor so he can have his recommendations ready during the blue-print stage. In this way they can be incorporated in the plans, thus allowing the engineering and operating men to make allowances for them.

Now assuming management has been sold on the fact it needs some help on its corrosion problems, has employed what it thinks to be the proper personnel, and has made the necessary plans in the organization so that the corrosion engineer can function properly—then management can expect and should get some real results.

First, management should expect, after due course of time, considerable reduction in replacement costs. Let me say right here that the two main functions of a corrosion engineer, so far as management is concerned, are to reduce replacement costs and to keep management advised on recent materials and techniques of construction so that it may be as free from replacement costs in the future as practical. Maintenance, which includes repair and minor replacement, occurs at any time and any place. It is not possible for the engineer to see and recommend materials or methods on every case of trouble. It is not economical to build his staff so that this can be done. Management expects him to make everyone in the operating department corrosion prevention minded and to set up standard operating procedures with corrosion prevention in mind. This requires a selling job on the part of the engineer. He must not only demonstrate to the superintendents and foremen what he is trying to accomplish but he should also explain it in non-technical terms by analogies or simple diagrams. Once there is an understanding, a set of standard practices can be set up as a guide. Then the company is full of minor corrosion engineers and the corrosion mitigation program has made great strides. This will free the engineer of a lot of detail and give him time to ferret out solutions to problems that do not fit the pattern. He can then be the specialist he was hired to be.

Suggested savings can only be realized by the engineer recommending materials and procedures that will combat corrosion. He should also keep management informed as to the newest and best methods for minimizing replacement and should be available for consultation in all new installations and expansions. It is expected that the engineer will make any tests necessary and secure enough information to recommend materials and procedures prior to the purchase of materials or the letting of a contract. To do this he will have to keep current on all late developments pertaining to the business.

Two ways of accomplishing this are immediately apparent: first, to read publications on corrosion, brochures on all types of testing equipment and materials for corrosion mitigation, and house organs from like or competitive organizations; and second, to make all possible contacts with others in the corrosion field through national associations and their local units such as NACE and corrosion groups within industries, such as the American Gas Association.

Experience of those operating the plant should not

be overlooked, and operating personnel should be consulted concerning the feasibility of the proposals. A system which looks good on paper or which has been successful in another section of the country may fail miserably in the case at hand. Chances are that unless the method is revolutionarily new, something like it has already been tried by the operating department. Close cooperation and free exchange of information should be expected between the corrosion engineer and the operating department.

Management should expect from the corrosion engineer written reports which are based on data obtained by the use of instruments. These reports should be so prepared that they are not too technical for the management to comprehend because if they are of such nature the man who is supposed to read them and pass judgment on the recommendations made will lose interest in the whole matter and throw it aside without really finding out what it is all about. The ability to write a good report is an art and should be considered seriously by every engineer because his future value to his employer depends largely on his ability along these lines. In order to make a good report it is necessary that the engineer have a general overall knowledge of the plant and its operations. This is also desirable so he can work safely within the plant and operate independently. It is also expected that he should know the language of the business, how things are done, the location and function of the various units, and the hazards involved. He is also expected to be both observing and critical of all operations within the plant, so that thereby he may approve those procedures that are currently considered good practice and recommend changes for outmoded or excessively expensive methods or materials. However, he must stay within his province and concern himself with matters of corrosion only.

In conclusion, I think the corrosion engineer is very rapidly becoming an important employee in many industrial organizations, and is now looked upon with respect by management; however, he must ever be on his toes and justify his services by the dollars saved through the adoption of his recommendations. If given a chance, he can save thousands of dollars in decreased cost of maintenance and decreased loss in production. His past record of accomplishment is generally excellent. His future accomplishments should establish the corrosion engineer as a necessary employee and an invaluable assistant to management.

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Preventing Corrosion with Protective Paint Coatings*

By GEORGE DIEHLMAN* and E. L. BEENFELDT**

Abstract

Red lead, the best known corrosion inhibitive pigment and the one with the longest record of successful performance, is used as the sole pigment or in combination with other pigments incorporated in a suitable binding medium or vehicle. It is used to keep the metal surface in a non-corroding or passive state.

To reduce painting costs, protective coatings should be carefully applied to a properly prepared surface. Factors to be considered in formulation and proper use of red lead paints are given, and for guidance of the maintenance engineer, a classification of red lead paints according to intended exposure conditions, and a reference listing of current specifications useful as a procurement basis is included.

Factors governing performance of paint coatings are listed as: Nature of metal to be coated, surface preparation, intended environmental conditions and paints, primers, topcoats. Illustrations show results after exposure of several surface preparation methods and application schedules. Protective paint systems for principal exposures are recommended, and a guide for selection of the correct red lead paint keyed to environments is given in tabular form.

THE PROBLEM of metallic corrosion and its control are matters of concern to every practicing engineer. If inadequate protective measures are used, the consequences of corrosion can be very costly.

Foremost among the materials used for preventing corrosion are protective paint coatings. It is almost inevitable that those who deal with corrosion problems will at one time or another have occasion to use corrosion inhibitive paints as a media of protection. Corrosion inhibitive paints, or primers as they are frequently referred to, depend primarily upon the inclusion of a corrosion inhibitive pigment to keep the metal surface in a non-corroding or passive state.

The best known corrosion inhibitive pigment and the one with the longest record of successful performance is red lead. Red Lead is used as the sole pigment or in combination with other pigments incorporated in a suitable binding medium or vehicle. The choice of vehicle is generally determined by the environmental conditions of intended exposure and the surface condition of the metal to be protected.

In the face of increasing costs, engineering and management personnel are vitally interested in minimizing paint maintenance. With metal protective coatings, this can be achieved only by carefully applying properly designed paints of first quality to well prepared surfaces under good conditions.

For the purpose of assisting the engineer select the most suitable paints so maintenance costs may be minimized, this article is centered on factors to be considered in the formulation and proper use of red lead paints and paint systems in general and also includes for the guidance of the maintenance engineer a classification of red lead paints according to intended exposure environment including a reference listing of current specifications which can be used as a basis for procurement.

Factors Governing Performance of Paint Coatings

Briefly stated, the important factors which should receive careful attention to obtain long-time protection with paint coatings are:

1. The nature of the base metal to be protected.
2. Surface preparation of the metal for painting.
3. Intended environmental conditions of exposure.
4. Paints—primers, topcoats—their application and functions in paint systems.

The order in which these factors were given is not of significance. All must be considered. Neglect of any one can be costly because such neglect will be reflected in a reduction of protective performance.

1. **Base Metal**—Proper classifications of the base metal to be coated is important. Is it steel, aluminum, galvanized steel (zinc), an alloy, etc.? If, for example it is steel, is it in the form of sheet—large structural shapes or something else—also has it been cold rolled or hot rolled? Is it already constructed or is it going to be constructed into a storage tank, pipeline, or some other structure? The composition, structure and physical state of the metal governs to a considerable extent the selection of the paints which will comprise the protective coating system and also the type of surface preparation the metal should receive prior to painting.

2. **Surface Preparation**—Much has been written on the subject of surface preparation.[1,2,3] There is practically unanimous agreement that thorough removal of all surface contaminants is necessary to realize the maximum protective performance from paint coatings. A poorly prepared metal surface can cause a normally excellent paint system to perform so poorly that the quality of the paints is often erroneously suspected. Frequently for economical or for certain other reasons, it is not feasible to completely remove all surface contaminants such as rust, mill scale, etc. In such cases, preparation should be as thorough as possible by the cleaning method used. For such surfaces, it is most important that the first

★ Submitted for publication January 12, 1951.
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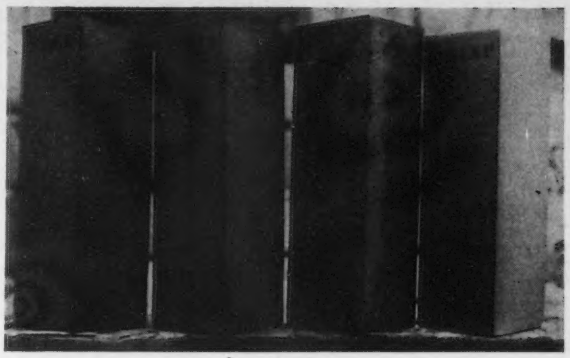
paint coat possess good penetrating and bonding characteristics if a firmly adherent foundation is to be established for the subsequent paint coats.

Figure 1 illustrates the comparative performance of a synthetic resin type paint applied to steel specimens representing four different surface conditions and shows the advantage of applying such paint to a thoroughly cleaned or intact surface.

The priming paint used on the structural shapes shown in Figure 1 was composed of 75 percent Red Lead—25 percent Iron Oxide by weight in a medium oil length linseed glyceryl phthalate alkyd containing 32 percent phthalic anhydride. One coat was applied at 2 mils (±10%). Exposure was at 45° angle facing south for nineteen months. The outstanding protection afforded by the paint on a thoroughly cleaned surface is obvious (right end specimen). Where the mill scale is essentially intact which is unusual in practice, the paint protected reasonably well (left end specimen). Where the paint was applied to partially corroded surfaces, protection was very poor (two center specimens). The adverse performance of the paint on the rusted surfaces can be centered on the faster drying oleoresinous vehicle and is typical for synthetic resin and high polymer type vehicles generally. They have poor penetrating and bonding characteristics on rusted surfaces and should be applied only to carefully cleaned surfaces if full benefit of their desirable properties is to be realized. These statements should not be interpreted as a condemnation of resinous-like vehicles but rather as a precaution to insure proper usage. For structures exposed to atmosphere, primers in which the vehicle is wholly or substantially unpolymerized linseed oil, perform much more satisfactorily on steel surfaces carrying corrosion products found impractical to remove.

Figure 2 shows the performance of a red lead-iron oxide primer coat similar to that described under Figure 1 except that the vehicle comprises raw and bodied linseed oils (9 to 1 ratio by weight). One coat of paint at 2 mils (±10%) dry film thickness. Specimens were exposed to industrial atmosphere at a 45° angle facing south for nineteen months during same period and under same conditions as specimens shown in Figure 1. The advantages of using a red lead base-linseed oil type priming paint as compared with a synthetic resin vehicle type paint on steel surfaces from which corrosion products have not been thoroughly removed, is apparent (compare Figure 2 with Figure 1—two center specimens).

It is recognized that in general synthetic resin type vehicles provide films which have better impermeability, chemical resistance, drying, and durability as compared with linseed oil. However as previously mentioned, they do not have the wetting properties characteristic of the latter, and their performance in primer form on surfaces not completely freed of contaminants can be very unsatisfactory. One approach found to be effective in partially utilizing synthetic resin vehicles for wire brushed steel surfaces exposed to atmospheric conditions, is to first use a next-to-the-metal or priming coat of red lead paint in which the vehicle is wholly or partially free raw linseed oil.



1 2 3 4

Figure 1—Effect of surface condition on paint performance. (1 coat—2 mils dry film thickness) after 19 months exposure to industrial atmosphere. Surface conditions of the steel specimens prior to painting were as follows:

1. **Intact mill scale (not more than 10 percent rust and wire brushed).**
2. **Mill scale partially removed (30-50 percent) by rusting and wire brushed.**
3. **Mill scale partially removed (50-80 percent) by rusting and wire brushed.**
4. **Complete removal of surface contaminants by sandblasting or pickling.**

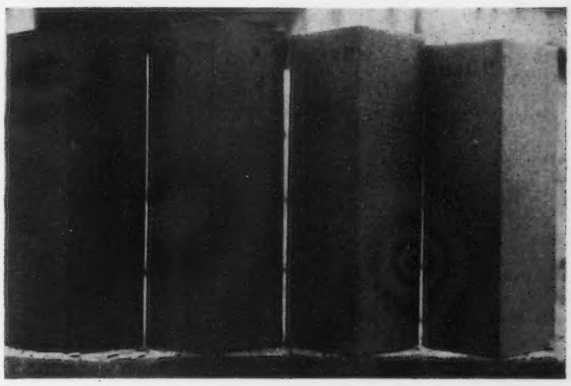


Figure 2

This establishes a firm bond with the metal base. When this coating is thoroughly dry, it can be followed with a second prime coat in which the vehicle is wholly of the synthetic resin type such as long oil alkyds, phenolics, etc. Examples are given in Table I—Guide to Selection and Use of Red Lead Paints, Note A. Another approach is more in the nature of a compromise and utilizes a vehicle which is part resin and part raw linseed oil. Examples of such paints are also shown in Table I, Paint Nos. 3, 4, and 5.

Where severe exposure conditions exist, the use of synthetic resin or other high polymer type paints throughout is required but application should be on well cleaned surfaces only.

3. **Environmental Conditions of Exposure**—The exposure conditions to which the structure will be subjected in service should be carefully checked and itemized and used as a basis for selecting the proper paint system. Usually the exposure conditions fit into one or more of the following:

TABLE I—Guide to Selection and Use of Typical Red Lead Base Paints

Type of Exposure	Paint No.	Type of Pigmentation	Type of Vehicle	Surface Preparation	Method of Application	Approximate Drying Time Between Coats
ATMOSPHERE	1	Red Lead.....	Full Linseed Oil.....	Wire brusing or better.	Brush or Spray.....	72 hrs. min.....
	2	Red Lead.....	Reduced Linseed Oil.....	Wire brushing or better.	Brush or Spray.....	36 hrs. min.....
Normal and Industrial (Refer to Note A)	3	Red Lead.....	Linseed-Glyceryl Phthalate Alkyd.....	Power wire brushing or better	Brush or Spray.....	18 hrs. min.....
	4	75% Red Lead 25% Iron Oxide	Linseed-Glyceryl Phthalate Alkyd	Power wire brushing or better	Brush, Spray or Dip.....	24 hrs. min.....
	5	65% Red Lead 15% Iron Oxide 20% Supplementary Pigments	Linseed-Glyceryl Phthalate Alkyd	Power wire brushing or better.	Brush, Spray or Dip.....	16 hrs. min.....
	6	Red Lead	Glyceryl Phthalate Alkyd (Medium Length)	1. Blasting to bright metal; 2. Brush-off Blasting;** 3. Thorough Power wire brushing.	Brush, Spray or Dip.....	5 hrs. min.....
Humid (Refer to Note B)	7	85% Red lead 15% Supplementary Pigments	25 gal. Tung Oil—Phenolic Varnish	1. Blasting to bright metal; 2. Brush-off Blasting;** 3 Thorough Power Wire Brushing.	Brush, Spray or Dip.....	6 hrs. min.....
Marine (Refer to Note C)	8	55% Red Lead 10% Zn. Chromate 35% Supplementary Pigments	Glyceryl Phthalate Alkyd (long oil)	Power wire brushing or better.	Brush, Spray or Dip.....	6 hrs. min.....
Strongly Chemical Contaminated (Refer to Note F)						
Water Immersion Saline or Sea Water (Refer to Note D)	9	Red Lead.....	Vinyl (Hydroxyl containing vinyl chloride-acetate copolymer)	Clean to bright metal such as by blasting.	Spray at temperatures from 5° F. and up.....	½ hr. min.....
Fresh, River, or Lake River (Refer to Note E)						
Solutions of Chemical or Other Chemically Contaminating Materials (Refer to Note F)						

LEGEND FOR REFERENCE MARKS:

* Tint alternate coats of the same red lead paint with the least amount of dry carbon black necessary to give a significant color change. This difference in color will prevent skips during application and thus insure full coat coverage.

** Brush-off sandblasting (dry or wet) is conducted similarly to regular commercial sandblasting except that the rate of cleaning is about two and one-half times faster. This method removes rust and loose mill scale but does not remove tight mill scale.

Note A: Frequently is it advantageous to use a next-to-the-metal-coat primarily for its penetrating and bonding characteristics to incompletely cleaned surfaces and follow this with a second red lead paint coat with a more water and chemical resistant vehicle. Examples are: Paint No. 1 or 2 followed by Paints No. 3, 4, or 5; Paints No. 3, 4, or 5 followed by Paints No. 6 or 7.

Note B: Where sandblasting of the steel surfaces is not feasible and some residual adherent rust or other corrosion products remain, such as would result from the wire brushing method of surface preparation, it is advisable to use as a first or next-to-the-metal-coat a red lead paint with good bonding characteristics such as Paints No. 3, 4, or 5 and then follow this with Paint No. 7 to shield out moisture. Where optimum resistance to water or water vapor is required, complete removal of all surface contaminants is necessary.

Note C: Red Lead Paints No. 1-6 are also effective in marine atmospheric environments when allowed ample drying time.

Note D: Red lead base paints utilizing coumarone-coal tar type vehicles, when properly formulated, are also effective anticorrosive coating materials. They can be applied by brush or spray and are less sensitive to surface condition of the metal.

Note E: Red lead base paints of the phenolic or vinyl types (Paint No. 8 and 10 respectively) are effective coating materials for these exposure conditions when properly applied on surfaces prepared as described.

Note F: Paints for these environments are generally formulated with rubber, vinyl or other high polymer type vehicles depending on the chemical contamination involved. Because of their specialized nature, it is suggested that such problems be referred to a reputable paint manufacturer for advice and recommendations.

Atmosphere: Essentially neutral as in rural areas, acidic as in industrial areas, intermittently saline due to proximity to sea water, alkaline or otherwise chemically contaminated as when in proximity to chemical processing operations, or some other unusual condition.

Water Immersion: Salt, neutral or fresh, or polluted with waste products of various kinds.

Alternate Atmosphere-Water Exposure: This may be a combination of any of the atmospheric or water conditions described.

Other factors which can adversely influence coating performance, such as materials having abrasive effects, should also be considered.

The corrosive action of these different environmental conditions is effectively retarded only when the protective paints are formulated to withstand the particular destructive actions involved. For instance, paints showing good performance on metal surfaces exposed in fresh water may fail miserably when exposed in saline (sea) water and vice versa.

4. **Paints, Primers, Topcoats—Their Application and Functions**—Generally, a metal protective system comprises multi-

TABLE I—Guide to Selection and Use of Typical Red Lead Base Paints

Reference Specifications for Procuring Required Red Lead Paints	Topcoat Paints—Suggested Types Pigmented to Required Color	SUGGESTED PAINT SYSTEM	
		Unpainted Steel	Repainting
Fed. Spec. TT-P-86; Am. Assoc. State Highway Officials 1950 Spec. M72-49, Type I.	Linseed Oil; long oil glyceryl phthalate alkyd; long oil phenolics and other long oil types.	2 coats Red Lead Paint;* 1 or 2 topcoats.	1 Patch Prime followed by 1 full coat of the same red lead paint; 1 or 2 topcoats.
Fed. Spec. TT-P-86a, Type I; Am. Water Works Assoc. Manual 7H.2T (Outside Surface); Am. Assoc. State Highway Officials 1950 Spec. M72-49, Type II.	See suggestions following Paint No. 1.	As for Paint No. 1 above.	As for Paint No. 1 above.
Am. Assoc. State Highway Officials 1950 Spec. M72-49, Type IV.	Linseed; medium or long oil varnish vehicles of types described for Paint No. 1 above.	As for Paint No. 1 above.	As for Paint No. 1 above.
Bethlehem Steel Company Spec. dated January 16, 1950.	As for Paint No. 3 above.	As for Paint No. 1 above.	As for Paint No. 1 above.
Fed. Spec. TT-P-86a, Type II; Am. Assoc. State Highway Officials 1950 Spec. M72-49, Type III.	As for Paint No. 3 above.	As for Paint No. 1 above.	As for Paint No. 1 above.
Fed. Spec. TT-P-86a, Type III.	As for Paint No. 3 above.	As for Paint No. 1 above.	As for Paint No. 1 above.
Fed. Spec. TT-P-86a, Type IV; Am. Water Works Assoc. Manual 7H.2T (For Water Tank Interiors).	As for Paint No. 3 above.	2 coats Red Lead Paint;* 1 or preferably 2 topcoats.	1 patch prime followed by 1 full coat of same red lead paint; 1 or preferably 2 topcoats.
Bureau of Ships, U. S. N. Formula No. 116.	Long or Medium oil glyceryl phthalatealkyds or other long or medium oil varnishes.	2 coats red Lead Base Paint;* 1 or 2 topcoats.	2 Patch coats or 1 patch coat followed by 1 full coat of the same Red Lead base paint; 1 or 2 topcoats.
Military Specification, MIL.-15929 (Ships); U. S. Coast Guard Spec. C. G. S. 52-P-4; Guide Specification (CE-1409), Civil Works Construction, U. S. Engineers, Formula V-101.	Red Lead—Vinyl Paint must be used over a metal conditioning coat (Military Spec. MIL-P-15328 (Ships) or U. S. Coast Guard Spec. C.G.S. 52-C-1). Where an antifouling topcoat paint is covered by specs. (BuShips, U.S.N., Formula No. 121 or U.S. Coast Guard 52-P-3).	1 coat Metal Conditioner (0.3-0.5 mils dry thickness); 2 coats Red Lead-Vinyl Paint (double pass each coat i.e. vertical and horizontal); 2 topcoats (double pass).	Use on previously applied vinyl system only. Apply metal conditioner to bare metal areas. Follow with red lead-vinyl paint as for Unpainted Steel. Two topcoats overall.
	1. Red Lead-Phenolic Paint can be used as a multiple coat self-system where topcoats of a particular color are not required. Where differently colored topcoats are required, the necessary pigments should be incorporated in a similar type of phenolic vehicle. 2. As in the case of the Red Lead-Phenolic paint, the Red Lead-Phenolic paint can be used as a self-system of multiple coats over the metal conditioner coat, or other colored vinyl topcoats may be used.	1. 2 or 4 coats Red Lead-Phenolic Paint* 2 coats Red Lead-Phenolic Paint* and 2 Phenolic topcoats of required color. 2. Red Lead-Vinyl Paint—as described for Paint No. 9.	1. Red Lead-Phenolic one patch prime followed by one full coat of same red lead paint. Two topcoats. Where multiple coats of the same paint comprise the system, the patch prime would be followed with 3 red lead-phenolic coats.* 2. Red lead-vinyl—as described for Paint No. 9.

ple coats of priming and topcoat paints. The protective performance of a paint system is dependent upon two main functions:

a. its ability to shield the metal from the corrosive environment
b. its ability to inhibit corrosion when the destructive environment does permeate the film.

Considering first the function of shielding the metal from the corrosive environment, this is most effectively realized by careful attention to several factors. Recognizing that the pigments contained in the paint have an important part, it is the vehicle or film forming portion which must make the major contribution in mechanically excluding the environment. The vehicles used must be such that they will be stable under the environmental conditions of exposure, and adaptable to the method of application. Increasing the film thickness of the coating, particularly by the use of multiple coats of paint, will result in a proportionate decrease in permeability and an increase in protective life. See Figure 3.

Where applicable, baking produces more impermeable films by imparting better film continuity and greater hardness. The topcoat paints, in addition to decorative value, should be designed to bear the brunt of the environment by offering maximum resistance to water or water vapor, abrasion, ultraviolet light and other destructive forces.

The ability of paint coatings applied at practical thicknesses to completely exclude the environmental factors responsible for corrosion is limited and varies for many reasons, some of which have been explained, i.e., film impermeability characteristics, porosity, film thickness, breaks caused by damage, etc. This leads to the second important function which a protective coating must possess, namely, the ability to inhibit corrosion. Inhibition is imparted through the inclusion in the priming coats of corrosion inhibitive pigments. The widest used corrosion inhibitive pigment and the one with a good record of practical performance is red lead. All types of vehicles may be used with red lead to cope with service conditions generally, and to provide primers meeting any drying speed requirement.

The priming paint must be formulated to provide not only adequate corrosion inhibitive properties but also to possess good penetrating and bonding characteristics so that it will adhere tenaciously to the

base metal and provide a sound foundation for subsequent paint coats.

Typical Protective Paint Systems

Atmospheric Exposure: With due consideration of surface condition and the extent of its preparation for painting as well as the intended exposure conditions, two coats of red lead-linseed oil paint or two coats of red lead-synthetic resin (straight or modified with raw linseed oil) followed by one or two finish coats utilizing a similar type of vehicle should provide long time protection. Refer to Table I.

Fresh Water Immersion or Humid Environments: Paint coatings (primer and topcoats) based on phenolic and modified phenolic vehicles have performed very well on steel structures subjected to these exposure conditions. A system based on the use of vinyl type resins is likewise very effective for structures subjected to immersion in fresh, river or lake waters. Lead pigments possessing basic characteristics such as red lead are excellent stabilizers for vinyls and are used to prevent their decomposition. Refer to Table I for description of system, surface preparation of the metal prior to painting and other related data.

Saline or Sea Water: Systems which have shown good performance are based on the use of vinyl resins or properly balanced coumarone-coal tar combinations, both types of which utilize red lead as the corrosion inhibitive constituent. Refer to Table I.

Severe Corrosive Environments: Conditions involving strong acids, alkalies, chemicals, certain petroleum products, sewage, etc., usually require paint coatings formulated with synthetic binders of the higher polymer types such as rubber, vinyls and their many modifications as well as others. Because of their unusual and specialized nature, these protective problems should be referred to a reputable paint manufacturer for his recommendations. Complete details regarding the exposure conditions should accompany such requests.

Application

This presentation would not be complete without mention of the importance of proper application under good conditions. It has been aptly stated that the greatest bottleneck to improved paint performance is lack of knowledge at the application level.[4] The operator should be sufficiently experienced to cross brush properly so that a uniformly thick film will be deposited. If application is by spray, the operator must be sure to lay down a uniformly thick film in each coat. Portable film thickness gauges are now available and provide a ready means of approximately checking dry film thickness in the field. Paints should be applied only to dry surfaces under good weather conditions. With certain exceptions paint should not be applied when the temperature is below 40° F. It is feasible with certain synthetic resin type vehicles, which depend on solvent evaporation alone to become stable films, to apply them at temperatures in excess of 5° F. The vinyls are typical of this latter group.

Selecting the Right Red Lead Paint

Red lead is included in many of the metal protective paint specifications of the Federal government as well as those of city, state, industry, and industry association establishments.

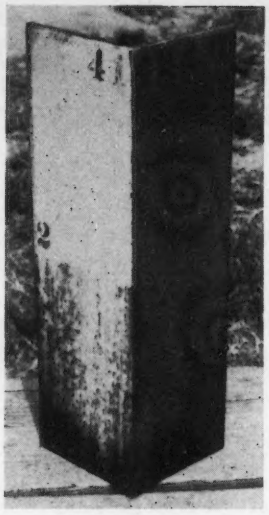


Figure 3—Relationship of film thickness to protective life—After eight years atmospheric exposure on steel.
Section 1—(lower left quarter) received one coat of primer only.
Section 2—(upper left quarter) received two coats of primer only.
Section 3—(upper right quarter) received two coats of primer and one standard finish coat.
Section 4—(lower right quarter) received one coat of primer and one coat of standard finish paint.
Section 3 is still offering complete protection.

As a guide for the engineer confronted with the problem of specifying a priming paint, a classification of typical red lead paints according to type of exposure is suggested in Table I. Included is a brief description of the pigmentation, the type of vehicle, kind of exposure suited for, preferred preparation of the metal surface, suggested paint system, and a listing of specifications covering the various types of red lead paints.

Summary

The factors which follow should be given careful consideration if the paint system selected is to provide maximum protection against metallic corrosion:

1. The composition, structure, and physical state of the base metal should be known.
2. Thorough preparation of the metal surface—preferably the complete removal of all surface contaminants.
3. Careful analysis of the environmental conditions of exposure.
4. The proper use of paints designed to cope with the corrosion problem involved.

If these basic factors are given the attention they deserve, economies in paint maintenance will be realized.

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A New Instrument For Measuring Galvanic Corrosion Currents*

By H. P. GODARD

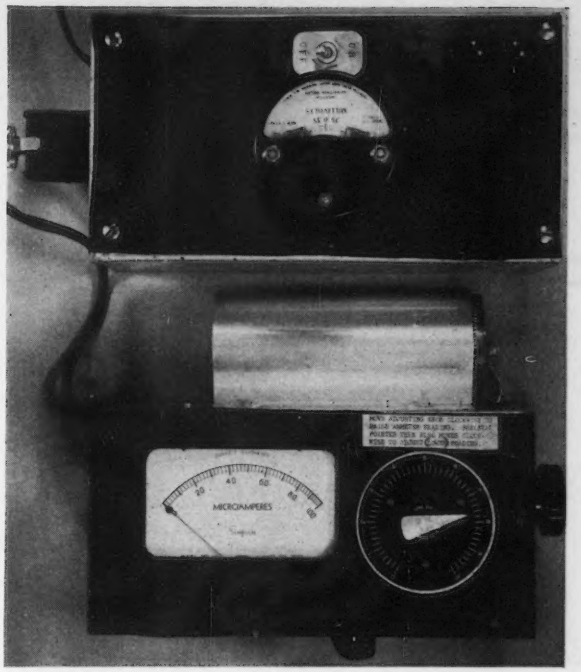

Figure 3—Automatic galvanic corrosion current apparatus.

HUGH P. GODARD—Head of the chemical division of Aluminum Laboratories, Ltd., graduated in chemical engineering (BA Sc 1936) and (MA Sc 1937) from University of British Columbia. He then attended McGill University from 1938 to 1941 working in the division of industrial and cellulose chemistry, graduating with a Ph D degree. During 1941-45 he was in charge of the explosives laboratory in a munitions plant for the Inspection Board of the United Kingdom and Canada. He has been with Aluminum Laboratories since 1945, is author of several technical papers, a member of several technical societies, a Fellow of the Canadian Institute of Chemistry and serves on the National Research Council's associate committee on corrosion research and control.

Introduction

GALVANIC CORROSION may be defined as the accelerated corrosion which one metal suffers when in contact with another, both being exposed to the same corrosive environment. In the most common case the two metals are in direct contact (e.g. a riveted or bolted joint, threaded connection, etc.) but galvanic corrosion will also occur when the different metals are separated, provided they are joined by a metallic connection through which current can flow. Galvanic corrosion usually results in accelerated corrosion of one metal of the pair and protection of the other. It is also known as "couple corrosion," "dissimilar metal corrosion," "bi-metallic corrosion," "contact corrosion" and sometimes "electrolytic corrosion" although the last named term is ambigious as it has been applied as well to other types of corrosion. A more detailed introduction to the subject has been given by Wesley and Brown.[1]

Galvanic corrosion is an extremely important factor in the design of machines, equipment and metallic structures which include several metals, and failure to take it into account often leads to premature failure, the time depending on the severity of the corrosive environment. This is especially true with the less noble metals such as magnesium, aluminum and zinc which usually act as the anode in a bi-metallic structure.

The relative galvanic behavior of metals varies with the environment, with the result that predictions based on the electromotive series are often in error. Probably the greatest amount of practical experience in galvanic behavior has been obtained in sea water and marine atmospheres, from which a seawater galvanic series has been developed.[2] This differs somewhat in order from the electromotive series.

In other less common environments and in fact in most specific cases, the galvanic relations between metals are not known and must be determined by experiment. Thus laboratory techniques for the accurate assessment of galvanic corrosion are of considerable practical importance although to date they have not received very wide attention in the technical literature.

Factors Influencing Galvanic Corrosion

1. *Solution Potentials*

The driving force for galvanic corrosion is the difference in solution potential for the two metals in contact in the particular environment under consideration. From Kirchoff's second law:

$$\Sigma(\text{E.M.F.}) = \Sigma(\text{IR}) \qquad (1$$

Ideally then, and if polarization is neglected (see discussion below):

$$E_a - E_c = I(R_e + R_m) \qquad (2$$

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Abstract

The theory of galvanic corrosion is reviewed briefly.

An apparatus for measuring the magnitude of a galvanic corrosion current is shown schematically with a brief description of the theory of application and procedure. It consists briefly of a pair of electrodes, a galvanometer connected across these electrodes, a dry cell, a variable resistor, an ammeter, and two switches so connected so that the true short circut current may be measured neglecting the measuring resistance. Also included are a simplified sketch of the final circuit, and the balancing circuit, along with a photograph of the corrosion current apparatus.

A practical application for the use of this instrument in measuring the protection offered to the core of an aluminum alloy by the less noble cladding material is described.

Tables giving the alloy composition of the materials tested and the average readings are included. A graph of the galvanic current plotted as an ordinate versus the logarithm of the time plotted as an abscissa showed pure aluminum cladding offered substantially more protection than the alloy material.

A similar graph was plotted showing the effect of cathode/anode ratio on current density. The effect of cathode/anode ratio on galvanic current is illustrated on a plot on current versus cathode/anode area. The straight line relation indicates cathode control of the galvanic cell.

Several other practical problems have been served by the application of this instrument in the author's laboratory. Seven references are included.

where

E_a = solution potential of anode
E_c = solution potential of cathode
I = corrosion current
R_e = resistance in electrolyte path
R_m = resistance in metal path

The amount of galvanic corrosion is directly proportional to the current flowing between the couple according to Faraday's Law:

$$W = \frac{tM}{Fn} I \qquad (3$$

W = grams metal dissolved from anode
t = seconds current flow
M = atomic weight of anode metal
F = Faraday Constant 96,500 coulombs
n = valence of metal ions formed
I = galvanic current in amperes

Of course, the loss in weight of the anode will usually be slightly greater than W because of the normal corrosion rate of the metal in the solution.

2. *Polarization*

However, in practice the open circuit solution potentials of anode and cathode are modified upon coupling by polarization. Depending on the couple and the environment, either the anode or cathode, or both, may polarize (polarization causes the potentials of anode and cathode to approach one another) and thus the degree of polarization will determine the effective driving potential for galvanic corrosion and hence the galvanic current in a given cell, where R_e and R_m are fixed. Unfortunately there is a paucity of published data on polarization characteristics of metals in most electrolytes, hence even if the solution potentials of both metals in a couple are known accurately for a particular environment, the severity of galvanic corrosion cannot be predicted with certainty. This is illustrated by the example of Whitmore and Teres[3] who found that although an 18-8 stainless steel was 0.19 volts more cathodic to aluminum in salt solution than brass (0.74 vs 0.55 volts) it induced much less galvanic corrosion of the aluminum upon exposure in seawater. This was due to polarization of the stainless-aluminum couple which reduced the effective voltage below that of the brass-aluminum couple.

Polarization tendencies can be assessed either by determining the potential-time curve for each electrode or by measuring the galvanic current-time curve. In the latter case no information will be obtained on which electrode is controlling the process.

3. *Relative Anode and Cathode Areas*

The larger the relative anode area in a given couple the less severe (i.e. in terms of intensity of local action) will be the galvanic corrosion of the anode owing to the reduced current density. Conversely there is likely to be serious galvanic corrosion when the anode area is small relative to the cathode area. The effects of relative area depending on the polarization characteristics of the couple are discussed at length by Wesley and Brown.[4]

4. *Diffusion*

In some instances diffusion at the electrode surfaces is the controlling factor in galvanic corrosion, i.e. either the rate of diffusion of oxygen to the cathode or the rate of diffusion of soluble corrosion products from the anode. It is thus important that laboratory galvanic corrosion tests parallel the expected service conditions in this respect or the results will be in error.

5. *Degree of Electrical Contact*

The two metals must be in electrical contact or galvanic corrosion will not develop. From equation (2 it is seen that other things being equal the resistance of the electrical path (R_m) can control the galvanic current. In service, corrosion products may form at the interface, break the electrical connection and stop further galvanic action.

6. *Conductivity of Electrolyte*

Also from equation (2 it is evident that R_e—the resistance of the electrolyte—is an important factor. In pure and many soft waters there is little galvanic action because of their high resistance. Hard surface waters have better conductivity and tend to increase galvanic action. Seawater with 3½ percent dissolved salts is a good conductor and leads to serious galvanic action.

Galvanic Corrosion Testing

As Borgmann[5] has pointed out, laboratory corrosion tests may usually be divided into five general types, according to what is being sought:

1) a study of the mechanism of corrosion
2) a selection of the most suitable metal for performance in a specific environment
3) a determination of the range of environments in which a given metal can be employed
4) a development of new alloys
5) a control test on quality of product

Galvanic corrosion testing is usually confined to types 2), 3), and 4). Means employed have been summarized by LaQue and Cox[2] as follows:

1) Measurement of open circuit potential of the couple
2) Measurement of a coupled metal potential against a reference electrode
3) Measurement of direction and magnitude of the steady corrosion current
4) Comparison of pitting, weight losses and mechanical property losses of coupled and uncoupled specimens exposed under similar conditions
5) Determination of polarization characteristics of specimens in the testing solution.

Of these 1) is of limited value since the effects of polarization are an unknown factor. 2) and 5) give interesting and valuable information on the degree of polarization but no numerical values that can be converted into corrosion rates. 4) is probably the most commonly used method, but suffers the disadvantage that a large number of specimens must be employed to determine with certainty the steady corrosion rate. 3) has also been used extensively and has the advantage that a plot of the galvanic current-time curve indicates when a steady condition has been obtained after which no further readings need to be taken. It is also suitable to study the influence of various environmental variables on galvanic corrosion and to compare the relative amounts of galvanic corrosion between couples.

Galvanic Corrosion Current Measurement

In the past the magnitude of the galvanic corrosion current has usually been determined by measuring the potential drop across a fixed resistance inserted in the external circuit connecting the couple. In this case the current measured is always less than the true short circuit current because of the measuring resistance inserted. As Brown and Mears have pointed out[6] the error introduced is small where the slope of the current density-polarization curve for either anode or cathode is steep, but large where the curve slope is flat. To overcome this error they suggested use of a "zero resistance ammeter circuit," which is shown below:

Referring to Figure 1 the pair of electrodes C and D are connected through switch S_1 which, when closed, short circuits the cell. In this condition there is no potential difference between the electrodes and galvanometer G reads zero. When switch S_1 is opened and switch S_2 closed dry cell B tends to drive a current through variable resistance R_1 through the test cell and through ammeter A which thus registers the current flowing in the cell. Dry cell B is connected so that the impressed current flows in the same direction as the normal corrosion current for the couple in question. Variable resistance R is then adjusted to the point when galvanometer G reads zero—the condition of true short circuit. If R is varied either way a potential difference will be indicated by galvanometer G.

This general type of circuit was adopted for the work to be described. In preliminary experiments the switches S_1, S_2 and resistance R were operated manually. When the electrodes were first immersed,

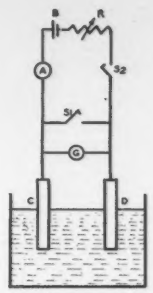

Figure 1—Zero resistance ammeter circuit.

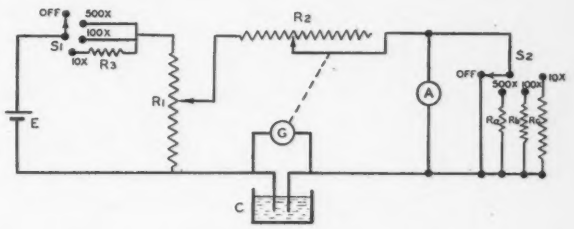

Figure 2—Simplified sketch of Final circuit.

E—1½ volt dry cell

R_1,R_2—2000 ohm circular rheostats (R_1 manually operated, R_2 motor driven)

S_1,S_2—a double-pole 5 position switch—4 positions used (one circuit on each side of switch)

G—Weston Sensitrol Model 705 Type N galvanometer relay

A—0—100 microammeter

R_a,R_b,R_c—range multiplying shunts for microammeter to give full scale readings of 1 mA, 10 mA, 50 mA

C—corrosion cell

R_s—additional 270 ohm dropping resistor for low current range

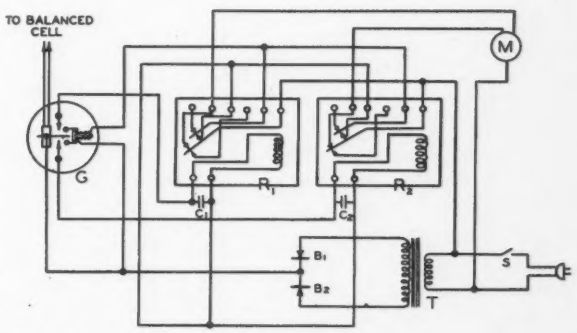

Figure 4—Diagram of a balancing circuit.

G—Weston Sensitrol relay model 705 Type N (double contact with solenoid reset, .15-0-.15 microamperes) serial no. S-35525

R_1, R_2—Weston model 712 Type 110 AC small power relays (with contacts rated at 5 amp 120V AC non-inductive) designed to operate from contacts of Sensitrol relays

C_1, C_2—50 mfd condensers for holding the Mod. 712 relays closed

B_1, B_2—selenium rectifiers. 75 mA rating

T—transformer with 0, 25, 50 volt secondary taps

S—power on-off switch

M—Bodine 3-wire reversible synchronous motor type KYC-22 No. 1717095 volts 115 AC, 6 rpm, 7.5 watts, 6 cycle, 55 oz-in torque

Figure 5

switch S_1 was closed in short circuit. To take a cell current reading S_2 was closed, then S_1 opened and R adjusted so that G indicated zero. The current on A was read and the cell returned to short circuit by Closing S_1 and opening S_2.

Similar readings taken at various time intervals enabled plotting of the galvanic corrosion-time curve.

It will be appreciated that each time the cell was switched from short circuit to the ammeter circuit it was "out-of-balance" until R could be adjusted. However, as the cell approached steady operation, the change in current from one reading to another lessened and the degree of "out-of-balance" was reduced until finally the change in circuit required no manipulation of R.

The actual cell circuit finally adopted is shown in Figure 2. Switch S_1 (and connected resistance) provide different current ranges. R_1 was a manually operated rheostat and R_2 a second variable rheostat. Switch S_2 controlled the ammeter shunts and thus the range of the meter. Sensitive galvanometer G was made to control a relay which in turn caused a motor to drive R_2 to the position corresponding to zero potential across the electrodes.

The instrument is shown in Figure 3 and the balancing circuit in Figure 4.

While the foregoing description presents the ideal case, the galvanometer relay used had a "blind spot" of about $\pm$ 0.15 mv within which it was inoperative. This small amount of unbalance can be disregarded in work of this kind.

A bank of ten galvanic corrosion current test cells was then assembled with toggle switches so that the automatic zero resistance ammeter could be connected to any one of the cells, the other cells remaining in short circuit. In this way multiple tests could be made at one time, the "ammeter reader" being applied to each in turn at various time intervals to provide the data for the current-time curves.

Practical Application

For metal aircraft "skin" it is common to use "Alclad" aluminum sheet in which the cladding alloy is anodic to the core and offers cathodic protection at the edges and at scratches or other areas of damage. There has been some discussion as to whether Duralumin (an aluminum alloy containing about 4 percent copper) should be clad with pure (99.5 percent Al) metal, or with a strong alloy which gives a stronger overall product. Such an alloy is 55S (53S by American designation—contains magnesium and silicon).

To obtain information on the relative cathodic protection offered by the two types of cladding ten (five couples of each type) cells were set up in which 6 x 8-inch panels of 0.064-inch sheet were suspended one inch apart to give an immersed area of 70 sq. in. (450 cm^2) as shown in Figure 5.

The battery jars were filled with six liters of 5 percent NaCl solution and placed in a constant temperature bath at 25° C. The cell assemblies were set in place, one at a time, and an initial current reading taken. For the first several hours frequent current measurements were made, but after this the rate of current change slowed down and readings were taken only twice daily. After 7-8 days the galvanic currents had become steady and the test was discontinued. The cells remained in short circuit between readings.

The alloy compositions were:

PERCENT

	Cu	Fe	Mg	Mn	Si	Ti	Zn	Cr
99.5 Al	0.02	0.25	....	....	0.15	0.01	....	....
26S	4.41	0.39	0.38	0.85	0.81	....	0.08	....
55S	0.06	0.22	1.40	....	0.65	0.01	....	0.18

Both alloys were heat treated to the "T" condition (solution treatment at 510° C., cold water quenched and aged eight hours at 170° C.).

The solution potentials of the three alloys concerned were measured in N/1 NaCl containing 0.2N H_2O_2 at 25° C. using a saturated calomel half cell and were found to be:

	Volts
99.5 Al	—0.77
26S	—0.69
55S	—0.76

The readings in the multiple cells agreed closely and their averages agreed well in three successive runs. Indeed the three time-curves agreed so well that a single smooth curve could be drawn to represent all the results which are given in Table I.

The overall averages for both types of cladding are plotted in Figure 6.

TABLE I—Average Readings of 5 Cells—26S Cathodes

	MILLIAMPERES							
	1S Anodes				55S Anodes			
Immersion Time	1st Trial	2nd Trial	3rd Trial	Overall Avg.	1st Trial	2nd Trial	3rd Trial	Overall Avg.
3 min.	2.05	2.05	....	2.05	1.95	2.20	....	2.05
10 min.	1.45	1.80	1.10	1.45	1.20	1.90	0.98	1.36
20 min.	1.30	1.15	....	1.22	1.00	1.20	....	1.10
30 min.	....	1.30	1.10	1.20	....	1.20	1.00	1.10
60 min.	1.30	1.35	1.20	1.28	1.35	1.25	1.10	1.23
90 min.	....	1.40	1.30	1.35	....	1.35	1.20	1.27
120 min.	....	1.50	1.35	1.42	....	1.35	1.25	1.30
*25 hours	1.05	1.05	0.90	1.00	0.68	0.74	0.81	0.74
*50 hours	0.53	0.67	0.43	0.54	0.36	0.45	0.38	0.40
*74 hours	0.43	0.52	0.36	0.44	0.36	0.33	0.35	0.35
*92 hours	0.34	0.37	0.25	0.32	0.23	0.22	0.23	0.23
*140 hours	0.23	0.23	0.29	0.25	0.18	0.18	0.30	0.22
*164 hours	0.25	0.27	0.27	0.26	0.18	0.21	0.27	0.22

* These times are approximations only and were chosen to fit most closely for the three trials. Difference from exact time is one or two hours only, which for the longer immersion times is not significant.

This showed clearly that the pure (99.5 percent) aluminum cladding would be more protective to the Duralumin core in salt solution than would the alloy cladding—it supplied 18 percent more current after seven days under the test conditions. It is of interest that the solution potential of the pure aluminum is only 0.01 volts more anodic to Duralumin than the 55S alloy cladding—hardly enough to expect much difference in galvanic behavior. Yet a study of the corrosion current curves reveals a substantial difference in performance and illustrates the value of this technique in galvanic corrosion studies.

It should of course be recorded that this experiment has indicated only the relative degree of protection offered by the two types of cladding, but has given no information on how much protection is required in service, or whether 55S cladding is adequate in this respect.

The foregoing results were obtained with equal areas of anode and cathode. To determine the influence of relative cathode area (at a scratch on an Alclad surface there would be only a very small area of cathode exposed compared to a large anode area) a series of cells were prepared with cathode/anode areas varying from 1:8 to 1:1 and the current-time curves plotted as before. The results are given in Table II and plotted in Figure 7.

It is of interest to plot the steady corrosion currents against the cathode/anode ratio as has been done in Figure 8.

The straight line relation indicates cathodic control of the galvanic cell as predicted by Wesley and Brown.[7]

Other practical problems to which this instrument has been applied in the laboratory have been the selection of valve metals for aluminum beer barrels and the choice of aluminum alloys for automobile cylinder heads. In the latter case the apparatus was of especial value because the influence of environmental factors, such as cyclic operations, on the galvanic current in a couple could be determined.

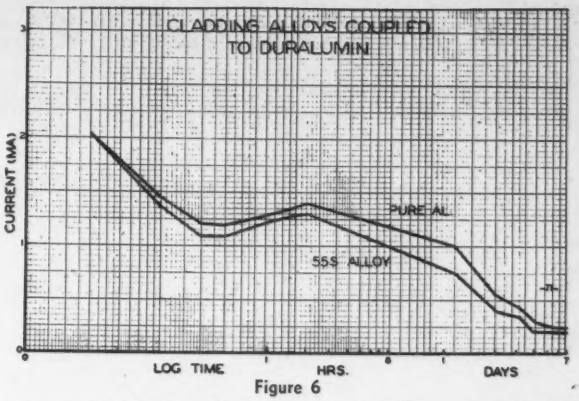

Figure 6

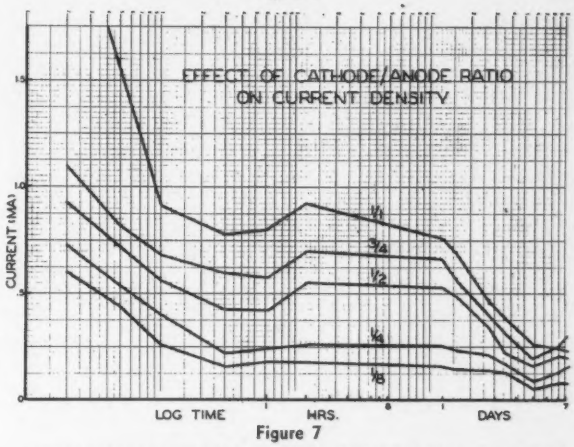

Figure 7

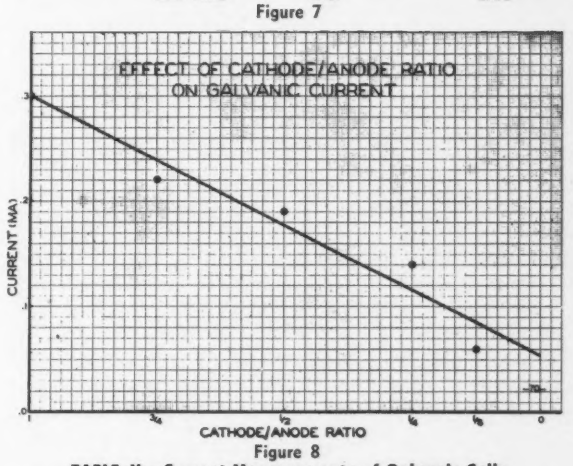

Figure 8

TABLE II—Current Measurements of Galvanic Cells With 26S Cathodes of Varying Size and Standard 1S Anodes*

	MILLIAMPERES				
Cell No.	1 & 2	3 & 4	5 & 6	7 & 8	9 & 10
Immersed Cathode Area in cm^2	55	110	220	330	450
Time					
2 min	0.60	0.73	0.94	1.10	2.70
5 min	0.42	0.52	0.72	0.83	....
10 min	0.26	0.40	0.56	0.68	0.91
30 min	0.15	0.21	0.43	0.60	0.77
60 min	0.17	0.24	0.42	0.58	0.80
2 hours	0.17	0.26	0.55	....	....
20 hours	0.15	0.25	0.53	0.66	0.76
26 hours	0.14	0.23	0.48	0.54	0.67
44 hours	0.14	0.21	0.34	0.39	0.45
51 hours	0.12	0.16	0.20	0.27	0.37
94 hours	0.04	0.09	0.16	0.17	0.20
144 hours	0.07	0.12	0.21	0.25	0.24
168 hours	0.06	0.14	0.19	0.22	0.30

* Area of anode 450 cm^2.

Acknowledgment

The author acknowledges the invaluable assistance of Dr. R. H. Hay who designed and constructed the balancing circuit.

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Thermofor Catalytic Cracking Gas Plant Corrosion Survey*

By CHRISTOPHER A. MURRAY

Introduction

DURING THE WAR and post war period there has been a great increase in the number of catalytic cracking units in petroleum refineries. The distinct advantage of these modern units is the economical production of high quality gasoline which the modern motor car demands. R. H. Newton et al[1] have described the Thermofor catalytic cracking process. The development of the catalytic cracking units has brought attendant corrosion problems which are more acute than those experienced in the older thermal units. These corrosion problems are magnified by current economic factors of high labor, high maintenance and high metal replacement costs and the need for steady, efficient, and economical production in a highly competitive market.

The economic aspects of refinery corrosion losses have been described by F. A. Rohrman.[2] Programs for reducing refinery corrosion by chemical neutralization have been outlined recently by E. Q. Camp and Cecil Philips,[3] and by H. L. Bedell and V. W. Hatchett.[4] Corrosion problems arising from fluid catalytic cracking have been discussed by Nathan Shofer.[5]

In the catalytic units, vapors of a heavy oil and steam are contacted at high temperatures, 900° F to 1000° F, with either a fixed or a moving bed catalyst to produce a cracking reaction. The cracked oil vapors and steam are cooled, and the cracked oil and gases are processed in various stages to produce desirable refinery gases, high octane gasoline, fuel oil and recycle stocks. Unfortunately, from the corrosion point of view, along with the desirable products obtained in the cracking operations, various undesirable corrosive chemicals are formed. These are usually hydrogen sulfide, ammonia and unidentified organic acidic compounds. The corrosive chemicals produce a variety of corrosion problems, particularly in the gas plant phase of the processing operation.

It is suspected that the type of catalytic process and the crude oil source of charge stock for any particular catalytic unit and refinery create corrosion problems individual to that combination. It is the purpose of this paper to outline briefly the corrosion history of the gas plant of a Thermofor catalytic cracking unit at the Pure Oil Company, Smiths Bluff Refinery, Nederland, Texas, and to detail the results of a corrosives survey which may form the basis of elimination of the most severe corrosion. While the findings may not have exact parallel in similar units of other refineries, it is hoped the method of approach to corrosion problems may prove of interest to others engaged in this work.

★ A paper presented at the South Central Regional Meeting, National Association of Corrosion Engineers, Dallas, Texas, October 3-4, 1949.

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Abstract

Severe corrosion has been experienced in a Thermofor catalytic cracking gas plant over several years. Representative inspection findings are outlined. A complete chemical survey of gas plant streams for amount and type of corrosives, together with water present, is given. Ammonia and hydrogen sulfide are indicated the principal corrosives present. These have caused corrosion of overhead condensing equipment. Some ammonia acid salts are present which have dissociated at reboiler temperatures to give acid conditions which have caused rapid attack of reboiler tubes. Measures are suggested to remove water, which will also remove the principal corrosive constituents at appropriate points in the system. Possible places for chemical injection are suggested to neutralize any traces of remaining corrosives.

Charge to the Gas Plant

A brief discussion of the charge to the reactor, products and subsequent initial separation of products, giving the source of charge to the gas plant may serve as an introduction to gas plant operation and corrosion problems. Hydrocarbon charge to the thermofor reactor is 10,000 barrels per day. Temperature of charge is 960° F with catalyst temperature of the same order. As previously indicated, it is in the cracking reaction in the reactor that the corrosives ammonia, hydrogen sulfide and organic acidic materials are formed, due to breakdown of parent compounds in the charge oil. The vapors from the cracking reaction, consisting of corrosives, cracked petroleum compounds and steam are quenched and passed into a fractionation tower. An initial separation of the various petroleum fractions takes place here. In the present discussion, only those corrosives plus hydrocarbons and steam which leave in the overhead stream of the cracked oil fractionation tower are of interest. These corrosives plus all hydrocarbon gases, the gasoline fraction and steam from the cracking unit charge together with steam used for stripping in the cracked oil tower leave this tower over-

head, and pass into the gas plant for final separation of hydrocarbon gases, gasoline, and water.

At this point it should be noted that for the refinery under discussion, there are two cracked oil towers. However, a single gas plant is used to process the overhead streams of both cracked oil towers.

The temperature of overhead products leaving the cracked oil towers is 270° F to 300° F, and thus far in the process, corrosion has not been severe due to the water present being in the form of steam. It is further on in the gas plant, as steam is cooled to water, that water and the corrosives combine to produce severe corrosion.

The Gas Plant

Figure 1 details the flow of the gas plant. If the equipment is first considered, it can be seen that this gas plant is conventional, with a depropanizer, an absorber, a debutanizer and a dependanizer as the fractionation towers. The gas plant has a compression system consisting of one low pressure and two high pressure compressors, 40 psi, 140 psi, and 400 psi respectively. There are various water separators, heat exchangers, coolers, and reboilers.

By reference to the flow sheet, the hydrocarbon stream flow through the gas plant may be traced. After passing through coolers and reaching a temperature of 115° F, hydrocarbon and water vapors, gasoline and entrained liquid water from the south cracked oil tower overhead pass through a gas and water separator. A large part of the entrained water flows to drain. The hydrocarbon gases plus water vapor pass to the first stage compressors in combination with similar products from the north cracked oil tower overhead separator. Liquid hydrocarbons plus some entrained water leave the south separator bottom and pass through heat exchange with depentanizer bottoms as charge to the depentanizer tower. At present the depentanizer tower is being operated as a debutanizer. Part of the depentanizer bottoms is used as absorption oil for the absorber and the balance, after combining with debutanizer bottoms and passing through a caustic wash, leaves the gas plant as stabilized gasoline. The overhead from the depentanizer combines with liquified gases from first and second stage compression as feed to the depropanizer feed accumulator.

After passing through coolers and reaching a temperature of 115° F, hydrocarbon and water vapors, gasoline and entrained liquid water from the north cracked oil tower overhead pass through a gas and water separator. A large part of the entrained water flows to drain. The hydrocarbon gases plus water vapor pass to the first stage compressors, being joined with similar gas from the south separator as indicated above. Liquid hydrocarbon plus some entrained water leave the north separator bottom and combine with liquefied gases from the first and second stage compression and with depentanizer overhead as feed to the depropanizer feed accumulator. Gases from both cracked oil tower overhead separators pass through first and second stage compression and join with other previously indicated feed to the depropanizer feed accumulator.

Gases from the depropanizer charge accumulator pass through a water separator and through third stage compressors. After this compression, gases and water are passed through the absorber where the gases are absorbed in depentanizer bottoms. Rich oil leaves the absorber bottoms and, combined with liquid from the depropanizer feed accumulator, receives heat from exchange with depropanizer bottoms and forms the charge to the depropanizer.

The depropanizer overhead passes through a cooler and then to the depropanizer reflux accumulator. Gases from the reflux accumulator leave the gas plant and are used or processed elsewhere in the refinery. Liquefied gas from this accumulator passes back to the depropanizer as reflux.

The bottoms stream from the depropanizer receives heat from the depropanizer reboiler. Part of the bottom stream returns to the depropanizer to furnish additional heat for fractionation and the balance is charged directly to the debutanizer.

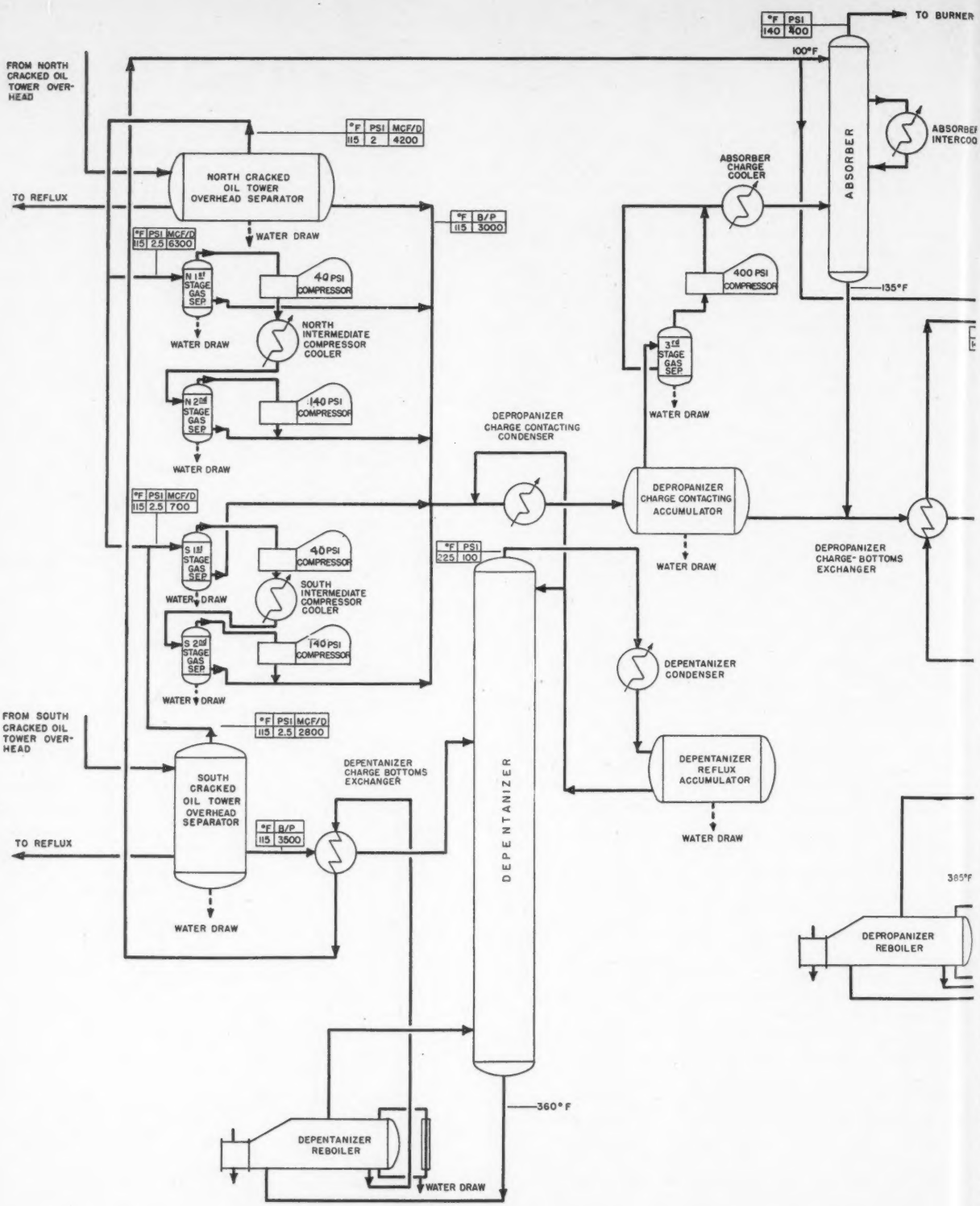
The debutanizer overhead passes through a cooler and then to a debutanizer reflux accumulator. Part of the liquid hydrocarbons from this accumulator pass back into the debutanizer as reflux. The balance is passed through a final cooler and is the finished butane-butylene fraction which leaves the gas plant. The bottom stream from the debutanizer receives heat from the debutanizer reboiler. Part of the bottom stream returns to the debutanizer to furnish additional heat for fractionation. The balance is passed through a debutanized gasoline cooler, combines with depentanizer bottoms, is caustic washed, and leaves the gas plant as stabilized gasoline.

Corrosion History in the Gas Plant

Corrosion has been severe in the coolers, heat exchangers, and reboilers of the gas plant. Major metal replacements have been necessary during shutdowns, with accompanying heavy costs. Also, unexpected failures have caused emergency shutdowns of the gas plant with the major expense of lost thruput added to the costs of metal replacement.

To indicate the extent of corrosion in the gas plant, abbreviated inspection records are given for selected tubular heat exchange equipment in Tables I through V. These records have been purposely selected as representative of the most and least corrosion experience in the gas plant. It will be apparent that corrosion has been severe in equipment serving both overhead and bottoms streams and that unsatisfactory corrosion losses have been general in the gas plant.

Before reviewing the inspection records, it should be noted that, due to war necessity, all original water cooled condensers and coolers were installed with ¾-inch steel tubes on a triangular pitch. This installation was contrary to The Pure Oil Company specifications for such service, which called for 1-inch Admiralty tubes on a square pitch. It was anticipated difficulties would arise from water side corrosion and fouling with an accompanying practical impossibility of cleaning the water side by drilling the small ¾-inch tubes. Similar practical impossibilities were apt to be involved with process side fouling,



which could not be removed by mechanical cleaning with tubes on a triangular pitch. Therefore, on such bundles, change was made from ¾-inch steel tubes on a triangular to ¾-inch or 1-inch Admiralty tubes on a square pitch as soon as either of the above circumstances inactivated a bundle. Records for the water cooled steel tube bundles are included for the indication of process side corrosion in some instances, although on the whole, water side corrosion was the limiting corrosion factor for these bundles.

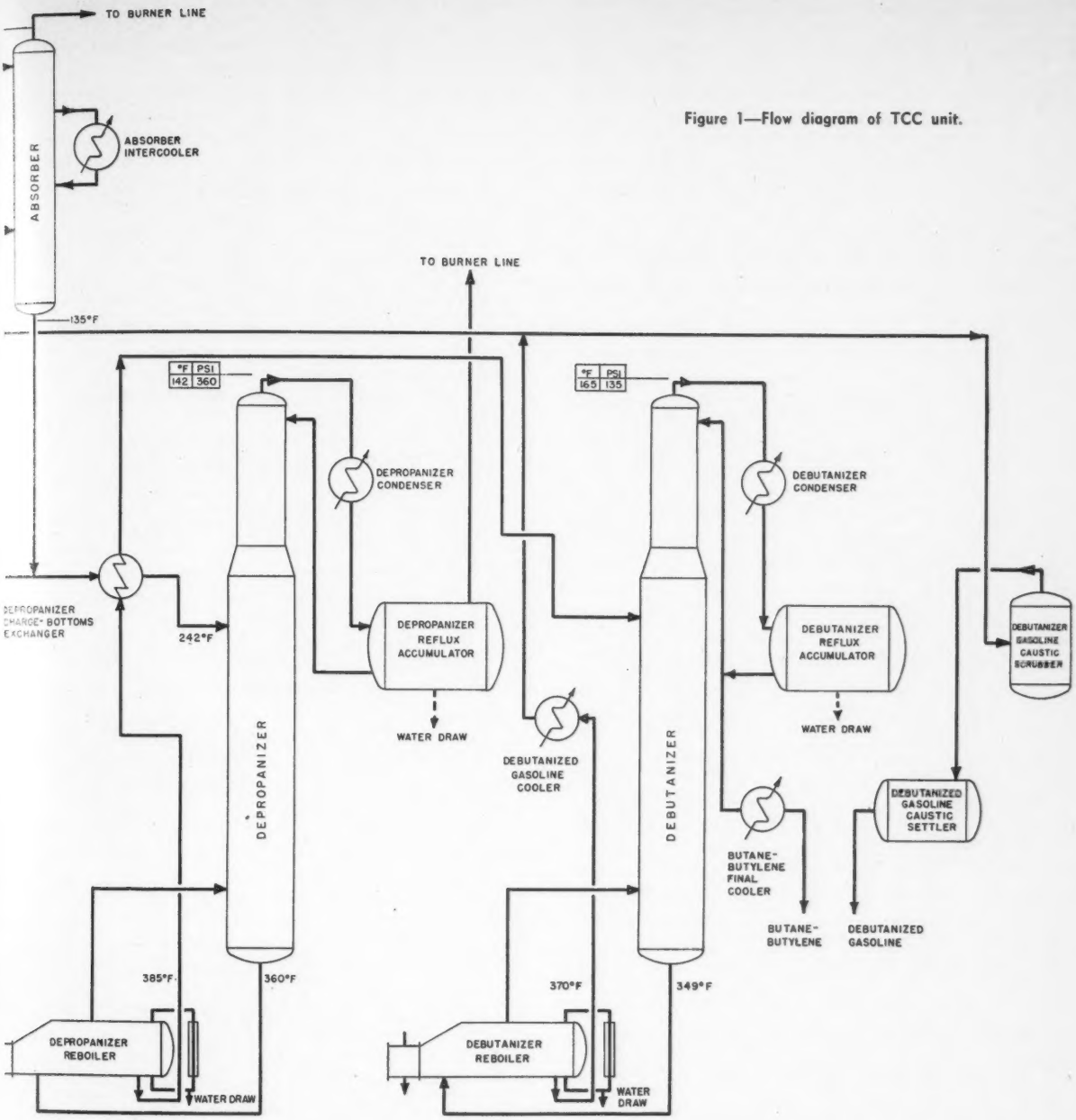


Figure 1—Flow diagram of TCC unit.

The inspection record in Table I indicates that the depropanizer overhead condenser was retubed with ¾-inch Admiralty instead of steel after fifteen months of service. Tube leaks developed in the Admiralty tubes within three months. After eleven months more service, the Admiralty bundle had to be bypassed. Service on a new 1-inch Admiralty bundle was nineteen months. The latest replacement bundle has had 70/30 copper-nickel tubes installed in the hope that crack failures would be avoided because of superior physical properties. To summarize, this bundle had to be retubed four times in five years and four months, having been out of service six months. It might be mentioned that the record of the twin bundle in this service is similar. It is significant that this bundle received most of the hydrogen sulfide, ammonia, and water passing through the gas plant.

The depropanizer charge-bottoms exchanger was retubed with Admiralty instead of steel after fifteen months of service. Corrosion then followed on the shell side of tubes and the stationary tube sheet, with the first pass having to be retubed within eight months. Corrosion continued and the bundle was retubed with 16 ga. Admiralty nine months later. This bundle was replaced in two months with a spare and the outlet end of the shell had been so corroded, a new one was provided. Four months later this bundle was replaced with the original bundle, now retubed.

TABLE I—Depropanizer Condenser Inspection Notes.

Substances Put Through: Tubes—cooling water; Shell—hydrocarbon vapors, water vapor, hydrogen sulfide, ammonia

Date	INSPECTION NOTES
1/1/44	New—steel tubes (wartime restrictions prevented the use of Admiralty tubes).
7/20/44	Pulled channel head and floating head. It was noticed copper gasket removed from floating head showed corrosion on edge exposed to propane.
4/1/45	Leaky tubes made bundle pulling necessary. Found bundle badly fouled between tubes and cleaning impossible. Decided at once to change from steel to Admiralty tubes (¾ by 16 ga.).
7/15/45	One tube leaked in bottom half of bundle; two tubes leaked in top half of bundle.
2/1/46	Three leaky tubes.
5/1/46	Leaky tubes. Eight tubes plugged.
5/27/46	Bundle developed more leaks. Entire unit removed from service. Bundle by-passed, with vapors direct to secondary depropanizer condenser.
3/1/47	New one-inch Admiralty tube bundle installed, and bundle put back in service.
8/11/48	One tube leak.
10/15/48	Bundle retubed. Old tube sheets and baffles were used. New 70/30 copper-nickel tubes used.
5/1/49	Hydrostatic test 585 lb. on shell side. Tubes apparently o.k.

TABLE II—Depropanizer Charge-Bottoms Exchanger Inspection Notes.

Substances Put Through: Tubes—bottoms liquid gasoline, water, ammonia, hydrogen sulfide. Shell—charge liquid gasoline, water ammonia, hydrogen sulfide.

Date	INSPECTION NOTES
1/1/44	New—steel tubes (wartime restrictions prevented the use of Admiralty tubes).
9/20/44	Tubes had been leaking on run. Pulled shell cover. Iron sulfide deposits ignited when opened. Several tubes corroded through at top of bundle near fixed tube sheet where hot liquid enters into first pass in tubes.
4/1/45	Bundle pulled. Several tubes found corroded through same location as above. Fixed tube sheet corroded on shell side. Spacers and baffles of bundle good. Shell good inside. Floating head, tube sheet, floating head cover, split ring and bolts in excellent condition. Bundle retubed with 14 ga. Admiralty.
7/15/45	Bundle pulled. Several tubes show corrosion 1/64-inch deep, more pronounced under outlet shell side. Shell looks good inside. Fixed tube sheet shows more corrosion on shell side. Channel head, shell head and floating head cover good. Tubes look perfect inside. Nozzles o.k.
12/15/45	Pulled bundle. First pass badly corroded on shell side. First pass retubed. Remainder of tubes had some corrosion scattered on outside. Inside of tubes look good.
5/1/46	Bundle pulled and cleaned. Outsides of tubes corroded, but not too badly. New tubes put in 12/15/45 about the same as rest of bundle. Inside of tubes look o.k.
9/1/46	Bundle pulled. Decided to retube. Outside of tubes corroded very badly. Retubed with 16 ga. Admiralty. Stationary tube sheet corroded very badly on shell side. About six baffles starting from stationary tube sheet are badly corroded. Others are fair.
11/27/46	Bundle pulled. Replaced with new spare. Outlet end of shell corroded below safe margin, so new one installed.
3/1/47	Bundle pulled. Replaced with old spare bundle with new tubes.
10/15/48	Bottom half of shell is pitted 1/32-inch. Replaced bundle with retubed spare.
5/1/49	Bundle pulled. Bottom of shell is pitted 1/32-inch. The area of greatest corrosion is in floating end of shell at bottom. Stationary tube sheet pitted 1/32-inch on tube side. Area of greatest corrosion on tubes at stationary tube sheet. Tubes rough and pitted 1/64-inch. Hydrostatic test 645 lb. on tubes, and 720 lb. on shell. No tube failures.

TABLE III—Depentanizer Condenser Inspection Notes.

Substances Put Through: Tubes—cooling water. Shell—hydrocarbon vapors, water vapor, hydrogen sulfide, ammonia.

Date	INSPECTION NOTES
1/1/44	New—steel tubes (wartime restrictions prevented the use of Admiralty tubes).
11/1/44	Replaced steel tubes with Admiralty tubes.
4/1/45	Tested o.k. no tubes failures.
9/1/46	Tested o.k. no tube failures.
3/1/47	Bundle pulled. Parts of bundle very bad. New bundle installed at this time. Shell at both ends pitted approximately 1/32-inch, especially on bottom half.
12/15/48	Shell in good condition with slight corrosion in bottom of shell twelve inches wide and extending the length of shell. Shell cover has 1/16-inch corrosion scale with slight pitting. Same on floating head cover. Steel baffles good. Admiralty one-inch tubes smooth inside and outside.
7/1/49	Cast steel floating head cover has minor corrosion and pitting on shell side of bundle. No change in shell.

Ten and one-half months later, this bundle was replaced with a retubed spare. Corrosion continues to be experienced on this exchanger. To summarize, this bundle had to be retubed or replaced with a spare five times in five years, four and one-half months, with shell side accessories also experiencing severe corrosion and necessitating some replacements. It is significant that this bundle received on the shell side most of the hydrogen sulfide, ammonia, and water passing through the gas plant.

TABLE IV—Absorber Charge Cooler Inspection Notes.

Substances Put Through: Tubes—cooling water. Shell—liquefied hydrocarbon gases, hydrogen sulfide, ammonia.

Date	INSPECTION NOTES
1/1/44	New—steel tubes (wartime restrictions prevented the use of Admiralty tubes).
11/1/44	Floating head cover good, baffles good. Mild tube corrosion under shell inlet.
4/1/45	Bundle pulled and cleaned. Steel tubes were pretty well clogged outside under gas inlet. Shell good inside. Heavy scale on bottom.
7/15/45	Bundle pulled. Steel tubes pitted 1/32-inch deep outside. Bundle acid washed water side. Several leaks developed. Bundle retubed with steel tubes. Strong ammonia odor in shell and bundle.
9/1/46	Bundle pulled and cleaned. Tested o.k. no tube failures.
3/1/47	Bundle pulled and discarded as part of planned program of elimination of small diameter and triangular pitch bundles. New bundle with one-inch 70/30 copper-nickel tubes on square pitch installed.
10/15/48	Bundle pulled, cleaned, and inspected. Tube bundle looks very good. A very heavy and hard scale on outside of tubes. Tubes very rough under scale. Scale was not cleaned off.
5/1/49	Bundle pulled and cleaned. Tubes have uniform 1/64-inch scale outside. Tubes rough under scale. Minor corrosion in bottom of shell.

TABLE V—Debutanizer Reboiler Inspection Notes.

Substances Put Through: Tubes—steam. Shell—liquid gasoline, water organic acids.

Date	INSPECTION NOTES
1/1/44	New—steel tubes, hairpin type, with no floating tube sheet.
7/15/45	Bundle retubed with steel tubes. Corrosion outside tubes with several holes found in tubes. Tube sheet and baffles perfect.
4/2/46	Found tubes on bottom corroded through. Retubed with 14-ga. steel tubes. Used old baffles and tube sheet. Also built up two circumferential welds in bottom of shell with 19/9 chrome nickel steel welding rod.
9/1/46	Bundle pulled. New spare bundle installed with steel tubes.
11/30/46	Bundle cleaned. Turned over because tubes on bottom had several deep pits. Outside row of tubes plugged for safety.
3/1/47	New steel tube bundle installed.
8/1/48	Tested o.k. no tube failures.
9/8/48	Tested o.k. no tube failures.
10/15/48	Tube bundle in fair shape, but due to heavy tool marks on tube sheet gasket faces decided to install new retubed steel bundle.
11/23/48	Found 25 tubes leaking in the roll. They were re-expanded, and one tube was plugged off.
1/26/49	One hairpin bend leaking. Re-expanded fifteen leaky rolls.
1/31/49	Bundle leaking and was replaced with partially retubed bundle. A one-inch weep hole was cut on the bottom of the weir in shell. Notches were cut in the bottom of each baffle in bundle in an attempt to prevent building up of sludge in bottom of shell.
5/1/49	New tubes put in on 1/31/49 show little corrosion and pitting (1/64-inch). Minimum outside diameter on new tubes 0.746 inches; minimum on old tubes 0.740 inches. Shell and bundle were clean. Notches in baffles apparently successful in preventing accumulation of sludge.

It can be noted in Table III that the depentanizer condenser was retubed with Admiralty instead of steel after ten months of service. Following corrosion was moderate and retubing was not necessary for 28 months. At this time the shell was found pitted at both ends, especially on the bottom half. Nineteen and one-half months later, moderate corrosion had continued with some slight increase in shell pitting but with Admiralty tubes in good condition. To summarize, this bundle was retubed with Admiralty instead of steel after ten months of service and was retubed again with Admiralty 28 months later. Corrosion has been relatively moderate and it is considered significant that ordinarily not much water or great concentration of corrosives pass through this condenser.

From Table IV, it can be seen that the absorber charge cooler did not experience excessive process side corrosion the first few months of service. After sixteen and one-half months of service, steel tubes

were pitted 1/32-inch and the tubes developed several leaks after a water-side acid cleaning. Evidently both process and water side corrosion had occurred. Products of corrosion from elsewhere in the system had clogged the gas inlet tubes, and corresponding scale was found on the bottom of the shell. At this time the bundle was retubed with steel tubes. Further corrosion was not severe on the process side. After eighteen and one-half months service, a one-inch 70/30 copper-nickel bundle was installed to avoid possible Admiralty crack failures. In the ensuing 26 months, a hard 1/64-inch corrosion scale was formed on the outside of tubes. To summarize, this bundle was retubed with steel after sixteen and one-half months of service, and then with 70/30 copper-nickel after eighteen and one-half months of service. Corrosion on the process side was noticeable, but not to compare with that experienced in earlier or later streams of the gas plant. It is considered significant that considerable concentration of ammonia and hydrogen sulfide was present in water passing through this bundle.

The inspection record in Table V indicates that the debutanizer reboiler was retubed with steel tubes after six and one-half months of service. This bundle was retubed again after eight and one-half months further service. Five months later, it was necessary to install a spare bundle. Two months following, this bundle was turned over due to severe pitting of bottom tubes. Four months later a new bundle was installed. There was now a period of comparative freedom from trouble and it was not until seventeen and one-half months later that a new bundle was installed. This time, the reasons in part were not a result of corrosion. Three months later, and due to corrosion, the bundle was replaced with a spare. In the past four months, little corrosion has been experienced, due in part to corrective measures. To summarize, this bundle has been retubed or replaced six times in five years and one month. It is significant that this bundle has been continually exposed to high temperature and organic acid conditions.

To recapitulate for the five bundles described, and neglecting the conversion of steel tubes to Admiralty in water cooling service, one retubing was necessary every three and one-half months. The life of the average bundle was 18 months. The experience for the gas plant as a whole has been worse than these figures indicate, because but one example each of worst-to-best bundles has been given. Bundles in overhead stream service experienced severe corrosion as well as did bundles in bottom stream service. Bundles in intermediate stream service experienced moderately severe corrosion. The inspection records indicate that a severe corrosion situation exists throughout the gas plant in the equipment described.

The Corrosives Survey

In order to have some basis for corrective measures, it was desired to learn more about the corrosive conditions existing in the gas plant. If inspection records generally indicated the place and amount of corrosion occurrence, it was felt a parallel record of type and amount of corrosives present might lead to successful corrosion prevention measures. Accordingly, a complete gas plant corrosion survey was made based on present operations.

The corrosives survey was designed to outline, within the limits of gas plant operation, the location and concentration of corrosives throughout the system. It was determined from previous analytical work that the principal corrosives present were hydrogen sulfide, ammonia and unidentified organic acids in water solution. Therefore, the concentrations in weight percent corrosives in water, plus water present in gallons per day were estimated for the various streams of the gas plant.

In order to obtain this information, all water draws off gas separators, feed and reflux accumulators, and reboilers were sampled and tested for pH, percent ammonia and percent hydrogen sulfide. Organic acids were estimated only where the pH of water was less than seven and the acids indicated to be present in a more or less free state. Where possible, estimates were made of the amount of water flowing to drains from gas separators and feed and reflux accumulators. In addition, estimates were made of the amounts of entrained water carried by liquid hydrocarbon streams. In the case of gas streams, calculations were made for water present based on the vapor pressure of the water at the temperature of the gas stream and the flow of gases. Not only were water streams tested for corrosives, but parallel analyses were made of hydrocarbon gas and hydrocarbon liquid streams.

The corrosives analyses, water flow data and hydrocarbon flow data, while not exact, are believed representative of average present operation in the gas plant and are thought sufficiently reliable for outlining the general corrosive survey. The data from the above tests, estimates, and calculations, are tabulated in Tables VI, VII and VIII, and are presented diagramatically on the flow diagrams in Figures 2, 3, and 4. Table VI and Figure 2 gives the data and flow diagram for corrosives present for the cracked oil towers separators, the first two compression stages, and the depentanizer system. Table VII and Figure 3 gives similar information for the 400 psi compression stage, and the absorber system. Table VIII and Figure 4 presents the corrosives survey for the depropanizer and debutanizer systems.

Overhead Streams Corrosives

It is evident from the overall corrosives survey data that ammonia and hydrogen sulfide are distributed throughout the gas plant in overhead streams. The concentration of ammonia and hydrogen sulfide in water which is causing corrosion in overhead streams may be traced from the data of the various water draws. In Figure 2, starting with the water draw of the north and south cracked oil towers overhead separators and progressing through the compressor system, the ammonia and hydrogen sulfide concentration in water draws increases as the gases are compressed in successive stages. Ammonia is more alkaline than hydrogen sulfide is acid. pHs remain on the alkaline side and the ammonia and hydrogen sulfide exist in the water as more or less

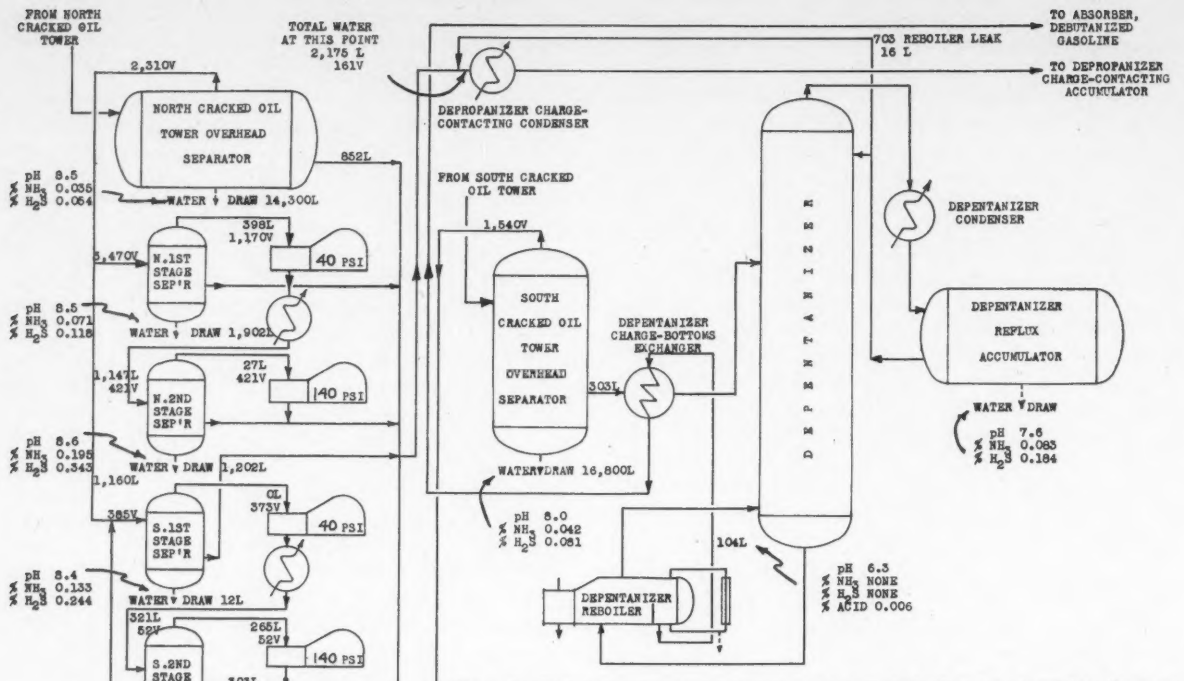


Figure 2—Flow diagram and corrosives survey for cracked oil towers, separators, first two compression stages and depentanizer. Water flow indicated in Gal/day. "L" indicates water in liquid state; "V" indicates water in vapor state.

TABLE VI—Gas Plant Corrosives Survey

For cracked oil towers separators, first two compression stages, and the depentanizer system.

VESSEL	Stream	Hydrocarbon Flow	Volume Percent Water	Water Flow Gal./Day	pH	Wt. Percent Ammonia	Weight Percent Sulfide
N. Cracked oil tower overhead separator	Overhead gas	4.2 MM ft³/SD	8.80	2,310 Vap.*		27 lb/SD	4,700 lb/SD
	Btms Gasoline	3,000 B/SD	0.677	852 Ent.*			4,700 71 lb/SD
	Btms water drain			14,300	8.4	0.035	0.054
S. Cracked oil tower overhead separator	Overhead gas	2.8 MM ft³/SD	8.80	1,540 Vap.		2.4 lb/SD	6,300 lb/SD
	Btms gasoline	3,500 B/SD	0.206	303 Ent.			86 lb/SD
	Btms water drain			16,800	8.0	0.042	0.081
N. Gas separator before first stage compression	Total Gas feed	6.3 MM ft³/SD	8.80	3,470 Vap.			
	Btms water drain			1,902			
	Total gas out	6.3 MM ft³/SD	3.15	1,170 Vap.	8.5	0.071	0.118
				398 Ent.			
N. Gas separator before second stage compression	Total gas feed	6.3 MM ft³/SD	1.16	421 Vap.			
				1,147 Ent.			
	Btms water drain			1,120			
	Total gas out	6.3 MM ft³/SD	1.16	421 Vap.,	8.6	0.195	0.343
				27 Ent.			
N. 2nd Stg. comp.	Total gas out	6.3 MM ft³/SD	0.331	119 Vap.,			
				329 Ent.			
S. Gas separator before first stage compression	Total gas feed	0.7 MM ft³/SD	8.80	385 Vap.,			
	Btms water drain			12			
	Total gas out	0.7 MM ft³/SD	3.15	130 Vap.,	8.4	0.133	0.244
				243 Ent.			
S. Gas separator before second stage compression	Total gas feed	0.7 MM ft³/SD	1.16	52 Vap.,			
				321 Ent.			
	Btms water drain			56			
	Total gas out	0.7 MM ft³/SD	1.16	52 Vap.,	8.5	0.199	0.343
				265 Ent.			
S. 2nd Stg. comp.	Total gas out	0.7 MM ft³/SD	0.331	42 Vap.,			
				275 Ent.			
Depentanizer	Total feed	3,000 B/SD	0.206	303			
	To reflux acc.	750 B/SD	0.632	199			
	Plus leak			703			
	Btms gasoline	2,830 B/SD	0.089	104	6.3	None	None
Depentanizer reflux accumulator	Water to drain			183	7.6	0.083	0.184
	Overhead gas	170 B/SD	0.224	16			
	Plus leak			703			

* Vap. indicates water vapor; Ent. indicates entrained water.

TABLE VII—Gas Plant Corrosives Survey
For 400-lb. compression stage and absorber system.

VESSEL	Stream	Hydrocarbon Flow	Volume Percent Water	Water Flow Gal./Day	pH	Weight Percent Ammonia	Weight Percent Hydrogen Sulfide
Depropanizer charge	Total gas feed	7.0 MM ft³/SD	0.331	161 Vap., 604 Ent.			
Accumulator	N. gasoline feed	3,000 B/SD	0.677	852 Ent.			
	Depent. OH			719 Ent.			
	Total of above feed			161 Vap., 2,175 Ent.			
	Btms water drain			200	8.5	0.301	0.534
	Btms gasoline	3,000 B/SD		1,770 Ent.			
	Drip gasoline	2,000 B/SD					
Gas separator before 400 lb. compression	Total gas feed	3.8 MM ft³/SD		358 Vap.			
		560 B/SD		8 Ent.			
	Btms water drain			8	8.5	0.380	0.681
	Total gas out	3.8 MM ft³/SD 560 B/SD		358 Vap.			
Absorber	Total gas feed	3.8 MM ft³/SD 560 B/SD		73 Vap., 285 Ent.			
	Depent. gasoline feed	1,000 B/SD	0.083	35 Ent.			
	Total gasoline out	2.8 MM ft³/SD 1,456 B/SD		320 Ent.			
	Total gas out	1.0 MM ft³/SD		73 Vap.			
	Intercooler water				7.3	0.143	0.336

TABLE VIII—Gas Plant Corrosives Survey
For depropanizer system and debutanizer system.

VESSEL	Stream	Hydrocarbon Flow	Volume Percent Water	Water Flow Gal./Day	pH	Weight Percent Ammonia	Weight Percent Hydrogen Sulfide
Depropanizer	Total feed	6,560 B/SD	0.759	2,090	9.1	0.543	0.791
	OH to reflux acc.	2.8 MM ft³/SD		1,800			
	Btms gasoline	6,560 B/SD	0.105	290	8.0	0.003	0.004
Depropanizer reflux accumulator	Water to drain				7.7	0.855	1.52
	Overhead gas	2.8 MM ft³/SD	Balance of hydrogen sulfide leaves this overhead				
Debutanizer	Total feed	6,560 B/SD	0.094	200	8.0	0.003	0.004
	OH to reflux acc.	1,500 B/SD	0.143	90			
	Btms gasoline	5,060 B/SD	0.094	200	5.5	None	None
Debutanizer reflux accumulator	Water to drain				8.8	0.006	0.004
	Butane-butylene	1,500 B/SD	0.132	83			

buffered solutions of ammonium hydrosulfide. In Figure 3, there are indicated substantial concentrations of corrosives in water passing through the absorption system. Figure 3 also indicates the considerable concentration of corrosives in water which is charged to the depropanizer. In Figure 4, it is indicated the greatest concentration of ammonia and hydrogen sulfide occur in the depropanizer reflux accumulator.

In overhead streams, the corrosion has been most severe where the greatest concentrations of ammonia and hydrogen sulfide occur in the water phase. However, such corrosion possibly is intimately related to the amount of water present and cannot be properly evaluated until the distribution of water in the gas plant is considered.

Overhead Stream Water

There are three main sources of water introduced to the gas plant, all of which may be noted in Figure 2. First, there is 3840 gal/day unavoidable water vapor introduced with the overhead of the cracked oil tower overhead separators. This water vapor is carried along with hydrocarbon gases through the compression stages, being in part condensed and drawn off at separators in the compression system. Second, there is 1155 gal/day avoidable entrained liquid water which is carried along with gasoline from the bottom of the cracked oil tower separators into the gas plant stripping system. Third, at the time this survey was made, a depentanizer reboiler leak was introducing 703 gal/day water into the depentanizer which carried overhead from the depentanizer to the depropanizer feed accumulator and on into the gas plant stripping system. Most of this water combines and is entrained with the hydrocarbon stream leading to the depropanizer charge accumulator. As already noted, the major part of the hydrogen sulfide and ammonia leaves the gas plant at this point.

It is significant that the worst overhead corrosion experience has been at points in the gas plant where the greatest amounts of water have carried the greatest concentrations of corrosives, namely, the depro-

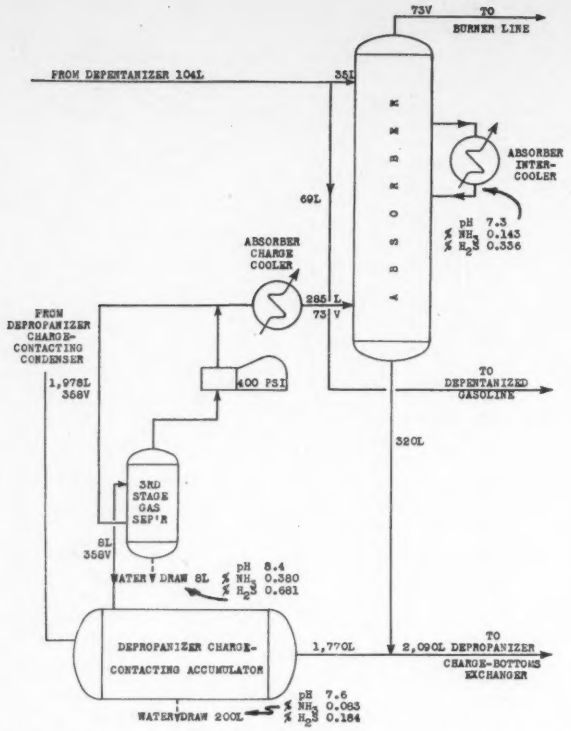


Figure 3—Flow diagram and corrosives survey for 400 psi compressor and absorber.

panizer charge contacting condenser, the depropanizer charge-bottoms exchanger, and the depropanizer condenser. Equivalent corrosion where less water has been present, has not been experienced in the depentanizer charge-bottoms exchanger, the depentanizer condenser, the absorber charge cooler, the absorber intercooler, the debutanizer condenser, or the butane-butylene final cooler. Overhead stream corrosion, therefore, is indicated intimately influenced by the amounts of water present and the comparatively high concentrations of corrosives in this water.

Bottom Stream Corrosives

It is evident from the data in Table VI and Figure 4, that bottom stream corrosion, such as has been experienced in reboilers, has been the result of an acidic condition which somehow exists at reboilers. The evidence of organic acids may be noticed in the lower pHs of the reboiler water draws, particularly those of the depentanizer and the debutanizer reboilers. In view of alkaline conditions in streams prior to the reboilers, some explanation is required for the presence of acid conditions at reboilers. Thorough contact of water both in the vapor and liquid state with hydrocarbon streams had been made earlier at the cracked oil towers. This thorough mixing had extracted all water soluble corrosives to the water phase from possible bottom liquid hydrocarbon streams. Laboratory tests have indicated this to be

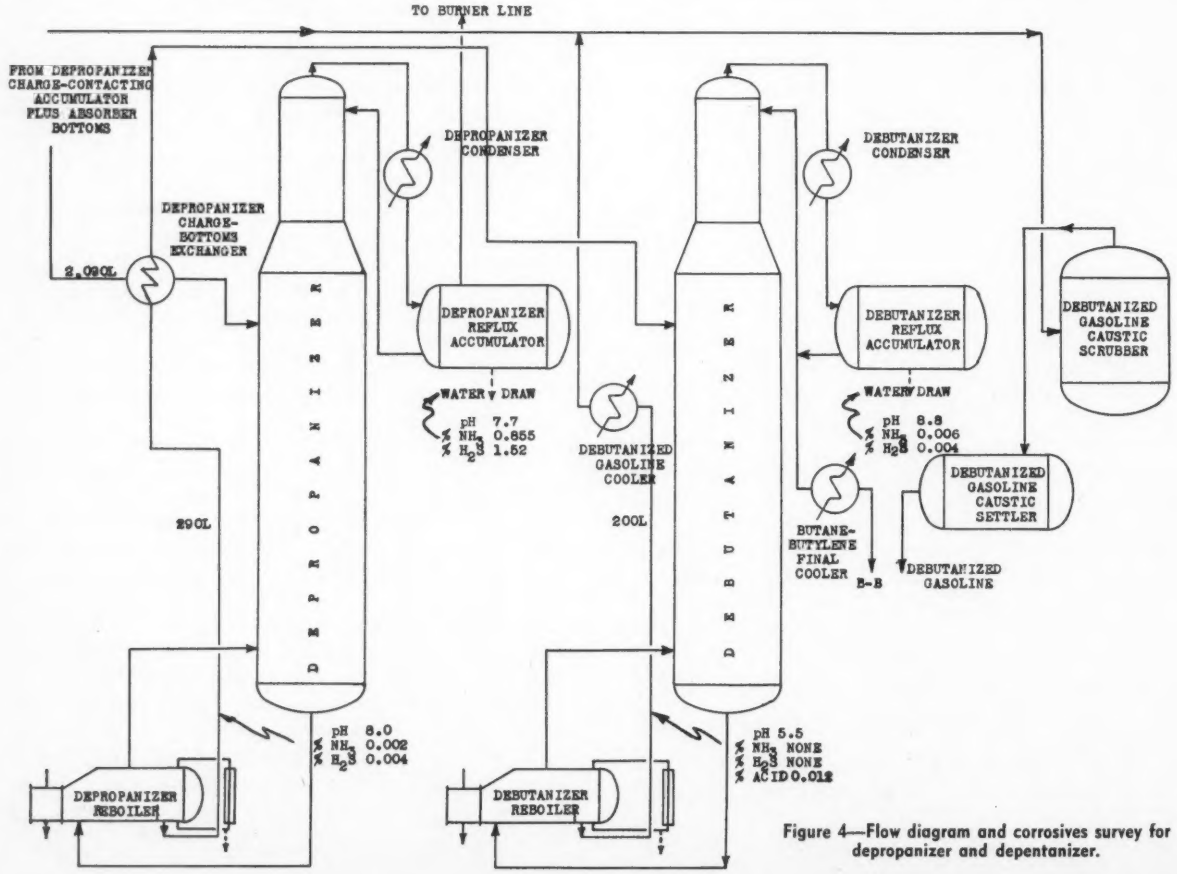


Figure 4—Flow diagram and corrosives survey for depropanizer and depentanizer.

the case. Both north and south cracked oil tower overhead separator gasoline streams were examined for ammonia and hydrogen sulfide and organic acids. No ammonia was found present and hydrogen sulfide content was equivalent to sixty pounds of caustic per 1000 barrels to neutralize. Other acid compounds were absent from the gasoline. It was therefore evident that strongly acidic corrosives were not present in bottom stream liquid hydrocarbons at this point, but were already extracted by ammonia to the water phase. Possible ammonia-organic acid salts in the water are indicated neutralized and dormant until the water has been carried further through the gas plant to the reboilers of the stripping towers.

The pH of the depentanizer reboiler water was found to be 6.3; that of the depropanizer reboiler was found to be 8.0; and that of the debutanizer reboiler was found to be 5.5. With evidence that corrosives are already extracted by ammonia to the water phase at a previous point in the gas plant, the conclusion may be drawn that acid conditions at the depentanizer and the debutanizer reboilers are entirely due to dissociation by heat of ammonium-organic acid salts carried by water to the reboilers. Temperatures at the depropanizer reboiler evidently were not sufficient to so dissociate the ammonium salts present that the water draw sample was acid.

Tests were made for the acidity of the depentanizer and debutanizer reboiler waters. The depentanizer water was 0.006 weight percent acid as acetic; and the debutanizer water was 0.012 weight percent acid as acetic. Further tests indicated the acid present was not of the common organic acid type such as acetic, proprionic, etc., but rather was some organic sulfur type, such as possibly dithioacetic acid. It is emphasized that pHs and percents acid are of water condensed and drawn from the reboilers. It is very possible pHs are lower and percents acid higher at reboiler tube surfaces, due to greater dissociation of ammonium salts by the higher temperatures present at tube surfaces. Consequently, corrosion rates should be expected to be greatly increased at the tube surfaces.

Bottom Stream Water

It has not been possible to adequately ascertain the flow of water through the reboilers. The once-through flow is readily enough determined. However, since it may exert a definite influence on corrosion experience, the possibility of some recycling of water between reboiler and tower should be noted. Once water is present in the reboiler stream, such recycling is definitely possible, and may greatly increase corrosion rates.

Metallic Sludge Influence On Reboiler Corrosion

A further definite accelerating influence on reboiler corrosion has been noted. At the time of a debutanizer reboiler failure in January, 1949, a site inspection indicated considerable iron sulfide sludge lodged at the bottom of the reboiler bundle and packed around the bottom reboiler tubes. Surface losses of bottom tubes which had been in the sludge averaged 0.020 inch. Surface losses of top tubes averaged 0.002 inch. The bottom tubes were severely pitted, while top tubes had slight uniform attack. Tubes of this bundle had been in service but three months.

It is indicated either that the sludge acted as a coalescing media for water, or that the sludge was cathodic to carbon steel and may have accelerated corrosion by galvanic effect. Likely both influences accelerated the corrosion. Of course the source of the sludge was due in part to corrosion of the tubes themselves; but the greatest part of the sludge was due to attack by ammonia and hydrogen sulfide further back in the system. Water in the system carried over sludge particles to the reboiler. Laboratory tests have also established the increased corrosion tendencies of such sludge.

To correct this corrosion, the sludge factor was reduced by notching the bottoms of baffle plates of the tube bundle, and by opening the weep hole of the baffle plate in the reboiler so as to encourage more thorough drainage of water and sludge to the outlet connection. This bundle was open to inspection in April. Little sludge was found, and no measureable metal loss had been experienced on the bottom row of tubes, the same row that had failed after being submerged in sludge from October to January.

Corrosives Survey Summary

The foregoing discussion of corrosives in the gas plant has indicated the following:

1) The corrosives ammonia and hydrogen sulfide are well distributed throughout the gas plant in overhead streams. Overhead stream corrosion is most severe where the greater concentrations of corrosives exist with the greatest amounts of water.
2) There are three sources of water which is introduced into the gas plant; unavoidable vapor with hydrocarbon gases, avoidable entrained water with hydrocarbon liquid, and avoidable water from a depentanizer reboiler leak.
3) The corrosives are present in the water phase.
4) Some water soluble ammonium-sulfur organic acid salts are present which dissociate at reboiler tube surfaces to produce an acid solution which corrodes reboiler tubes. Sludge from elsewhere in the system is carried to the reboilers by water and no doubt accelerate reboiler tube corrosion.

Corrosion Correction Measures

It is now apparent that once the inspection record is assembled, and once the corrosives survey is obtained, measures for corrosion prevention suggest themselves and may be outlined.

By reference to Figure 2 it is clear that the source of entrained water in liquid hydrocarbons may be substantially eliminated. Three hundred gallons per day of water is introduced with gasoline from the bottom of the south cracked oil tower overhead separator. It is suggested this water be removed with an

entrained water separator. Eight hundred and fifty gallons per day of water is introduced with gasoline from the bottom of the north cracked oil tower overhead separator. It is indicated more settling time should be provided this stream. With additional settling capacity provided, it is suggested any remaining entrained water be removed with an entrained water separator.

A further source of water in the gas plant consists of that resulting from condensation of water vapor during the various compression stages plus water from compressor house drips which becomes entrained in depropanizer charge accumulator hydrocarbon liquid. While water is removed at separators prior to compression and after the first stage compression, no water is removed at separators after the 140 psi or the 400 psi compression. It is suggested a flood nipple be provided the absorber bottom, with provisions for a water draw from the bottom of this tower. The remaining water may be removed prior to the depropanizer charge exchanger and it is suggested an entrained water separator be provided at this point.

It is to be expected that correcting corrosion difficulties will also correct depentanizer reboiler leaks. In connection with possible leaks in the depentanizer reboiler the following information should be of interest. The depentanizer reflux accumulator contains a six-inch flood nipple which will allow 95 gallons of water in the accumulator before the water overflows. The operating practice was to drain this accumulator once per shift. This was insufficient to remove water when any sizeable leak at all developed, such as several hundred gallons per day. Operating department instructions have been issued to drain this accumulator once every hour in the event of suspected leaks. This consideration applies equally well to the depropanizer charge accumulator from which large amounts of entrained water have been allowed to flow.

In addition to suggestions for water removal, the corrosives survey indicates possible measures for chemical neutralization. With water practically eliminated by the proposed measures, trace amounts of corrosives may remain in trace amounts of water. Corrosives present in water are then reduced to amounts where economical chemical injection is justified even with more expensive neutralizing agents. Overhead stream ammonia and hydrogen sulfide possibly may be chemically neutralized. Bottom stream ammonia-organic acid salts may be converted to salts less likely to dissociate with heat, such as sodium or amine salts. Provision for such chemical injection is therefore recommended at a point prior to the depropanizer charge-bottom exchanger.

Summary

A Thermofor catalytic cracking operation and gas plant flow has been described briefly to form a basis for description of gas plant corrosion and corrosives. Inspection records are given which illustrate the gas plant experience of metal loss and replacements. A corrosives survey to parallel inspection records has been outlined. The two records together offer suggestions for corrosion prevention measures. It has been found that the corrosives ammonia, hydrogen sulfide and organic sulfur acids are distributed throughout the gas plant in the water phase. Liquid hydrocarbon streams are substantially free of corrosives, the ammonia in the system having extracted them to the water phase. Overhead stream corrosion has been most severe at points of greatest concentration of ammonia and hydrogen sulfide in the greatest amounts of water. Bottom stream corrosion has been most severe where ammonium salts of organic sulfur acids dissociate to give acid conditions which may cause rapid attack of reboiler tubes. Reboiler tube corrosion is aggravated by sludge carry-over by water of sulfide corrosion products from elsewhere in the system. It is indicated that the principal foci of corrosion in the gas plant coincide with the presence of water.

The corrosives survey suggests measures to be taken to eliminate entrained water with added settling capacity and entrainment separators where water is present with liquid hydrocarbon streams. At points farther on in the gas plant where water and hydrocarbon vapors have been compressed to liquid, further water may be removed by installation of a flood nipple in the absorber tower and by installation of an entrainment separator ahead of the depropanizer charge-bottoms exchanger.

Corrosives remaining in the water phase and the amount of water remaining after proposed measures should be small. The corrosives survey indicates the type and place for chemical neutralization of these remaining corrosives.

Acknowledgment

The cooperation of Mssrs. W. S. Bedell of the inspection department, and M. A. Furth and J. G. Eckhouse of the technical department in furnishing charts and records and contributing to interpretation of the corrosives survey is gratefully acknowledged. The author also expresses appreciation to The Pure Oil Company for permission to prepare and publish this report.

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Discussions

Aerobic Microbiological Corrosion of Water Pipes, by Erik Olsen and Waclaw Szybalski. *Corrosion*, 6, No. 12, 405-414 (1950) Dec.

Discussion By F. N. Speller, Pittsburgh, Pa.:

The paper on Aerobic Microbiological Corrosion of Water Pipe by Olsen and Szybalski (CORROSION, Dec. 1950 p. 405) clearly shows how iron-bacteria facilitate the rapid formation of ferric hydroxide tubercles and that the formation of pits then proceeds by electrochemical action. They found that in the waters involved in this investigation, the filaments of iron-bacteria mechanically reinforce the membrance over anodic areas, but I believe it is too much to say that "filaments of iron-bacteria are always found in the tubercles" although that is no doubt the case within the field of this investigation. However, the water composition and temperature of the water, I believe are important factors.

Tubercles form in some hot water lines and boilers, where iron-bacteria would have a hard life. The crenothrix bacteria, I understand, do not function above 140° F or in sea water, but rust tubercles are not uncommon under these conditions. A marked difference in potential, due for instance to breaks in mill scale on submerged steel, may start the formation of rust tubercles over anodic spots. The ferric membrane is no doubt strengthened mechanically in the presence of iron-bacteria. It might be useful to know the inorganic contents of the tap water used in the author's experiments. While more work is needed on this problem, the authors of this paper have made a valuable contribution to the many useful references (mostly European) appended to their paper.

Reply by Waclaw Szybalski:

I fully agree with Dr. Speller's valuable remarks. We believe that the composition of water is of primary importance in the formation of the tubercles, as discussed in Addendum. The statement: "filaments of iron bacteria are always found in the tubercles" shall be restricted only to our investigations and to the papers discussed. The temperature also has some influence. We found that, in summer when water temperature is higher, the iron bacteria show more pronounced growth in pipes than in winter. Tuberculation in experimental pipes also starts much faster in summer. In hot water systems the growth of microorganisms is practically excluded as long as the high temperature is maintained. However, if the systems are flushed with cold tap water, (or used for cold water only over long periods of time, as was very often the case in Europe during the last war due to the coal shortage), the living bacteria are introduced and in a few days can possibly initiate corrosion, which afterwards will proceed even if the microorganisms are killed.

We believed that the iron bacteria are only one of the many factors, biological and otherwise, initiating (and maintaining) corrosion. In the case of our investigations the iron bacteria seemed to be an important factor.

In the microbiology of the natural environments, however, it is often very difficult to decide whether some phenomenon is caused by the growth of micoorganisms or if the phenomenon itself causes the microbial growth.

TABLE I

Saturation index (pH—pH_s)	—0.1+0.1	pH	7.6—7.8
Total hardness	16.6—19.6°H	Cl^-	56—92 ppm
Permanent hardness (1°H = 17.9 ppm)	0.6—3.1°H	SO_4^{++}	49—74 ppm
		SiO_2	16—18 ppm
Total solids	480—588 ppm	Fe^{++}	.02—.06 ppm
Dissolved oxygen	8.1—9 ppm		

I regret exceedingly that I have to answer Dr. Speller's remarks alone due to the recent unexpected death of Dr. Erik Olsen, one of the most prominent Danish microbiologists, whose friendship it was my honor and pleasure to share.

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The Influence of Stress on Corrosion by Julius J. Harwood. *Corrosion*, 6, No. 8 and 9, 249-259, 290-307 (1950) Aug., Sept.

Discussion by E. H. Dix,[1] R. H. Brown[2] and R. D. Williams,[3] Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa.

Mr. Harwood's paper published in the August and September issues of CORROSION is an excellent review of the information and theories of stress corrosion cracking. Inasmuch as this review shall continue to be a valuable reference on the subject of stress corrosion, we feel that some comments should be made on the Aluminum Research Laboratories' theory of stress corrosion cracking, especially to amplify and clarify some of the details which space did not permit Mr. Harwood to cover.

In the section devoted to "Theories of Stress Corrosion," Mr. Harwood has been objective in his approach and within the limitations of space has adequately presented the pertinent phases of the current theories. He has been particularly kind in his rather

1. Assistant Director of Research.
2. Chief, Chemical Metallurgy Division.
3. Chemical Metallurgy Division.

complete presentation of the work and publications of the Aluminum Research Laboratories.

From a historical viewpoint, it seems desirable to point out that the electrochemical theory of the mechanism of intergranular corrosion of aluminum-copper alloys was first conceived by L. J. Weber and E. H. Dix, Jr., of the Aluminum Research Laboratories. It was founded on the electrode potential relations involved in the development of Alclad products where it was found that pure aluminum is anodic to a solution heat treated, naturally aged, aluminum-copper alloy. The potential measurements were made by J. D. Edwards and C. S. Taylor (J. D. Edwards and C. S. Taylor, "Solution Potentials of Aluminum Alloys in Relation to Corrosion," *Transactions,* American Electrochemical Society, 1929, Vol. 56, p. 27) of the Aluminum Research Laboratories by measuring the potential difference between pure aluminum and variously heat treated aluminum-copper alloys. These measurements also showed that the artificially aged alloy 25S exhibited a smaller potential difference when coupled with pure aluminum than did the room temperature aged alloy 17S.

The Aluminum Research Laboratories' theory of the mechanism of intergranular corrosion was first published in 1928 (E. H. Dix, Jr., "Application of 'Alclad' Aluminum Alloy Sheet to the Aircraft Industry," *Aviation,* December 22, 1928). It was stated in the following words:

> Recent microscopic studies have given a clue to the explanation of the cause of intergranular corrosion of the heat treated strong aluminum alloys. It seems probable that within the grains of these alloys there exists a fine dispersion of sub-microscopic particles of several of the alloying constituents in a matrix of aluminum solid solution, while between the grain there exists a thin film of aluminum solid solution relatively free of precipitated particles. This analysis of a situation which exists beyond the field of resolution of the microscopic is drawn from an examination of specimens which have been so treated as to cause the precipitate to coalesce to a size, which is visible under a high power microscope. If this condition does exist, then our experiments regarding the solution potential of aluminum as compared to the alloy would indicate that there is a difference in solution potential between the material composing the grains and that at the grain boundaries, and that the direction of this potential would be such as to cause the solution of the metal at the grain boundaries to be greatly accelerated. The solution of the very small amount of metal in the grain boundaries would proceed rapidly and the corroding solution would be drawn by capillary attraction farther and farther below the surface, following always the films of purer aluminum along the grain boundaries. In this way, the strength and ductility of the alloy would be rapidly destroyed.

By 1940 Mr. R. H. Brown had developed the techniques that made it possible to measure the difference in electrode potential between grain boundaries and grains of coarse grain aluminum alloy samples. These measurements confirmed the early ideas of Weber and Dix and made possible the more complete statement of the mechanism of intergranular corrosion. During this period also, extensive investigations of the stress corrosion cracking tendencies of aluminum-copper and aluminum-magnesium alloys had been conducted at the Aluminum Research Laboratories. These investigations, coupled with the many discussions within the Aluminum Research Laboratories concerning the results obtained, led to the electrochemical theory of stress corrosion cracking as expressed in the 1940 Institute of Metals Division Lecture (E. H. Dix, Jr., "Acceleration of the Rate of Corrosion by High Constant Stresses," *Transactions,* American Institute of Mining and Metallurgical Engineers, 1940, Vol. 137, p. 11).

Mr. Harwood has stated that this theory was "first proposed *in this country* by Dix and his associates." He apparently felt it necessary to limit his statement to "this country" because of the work of German investigators. He refers to the report by C. A. Naugle (Charles A. Naugle, "German Theories and Accomplishments in the Field of Stress Corrosion Cracking," (Project No. NTE-31), June 1947, Technical Report No. F-TR-1131-ND, Headquarters Air Materiel Command). Actually, Naugle's article is mostly a quotation from Vosskuehler's 1944 report (H. Vosskuehler, "The Phenomenon and Significance of Stress Corrosion in the Wrought Aluminum Alloys," Research Report No. 33, 1944, Bitterfeld, am 13/3/1944). A careful study of the Vosskuehler report or other articles referred to in the bibliography of Naugle's report does not reveal any mention of zones of depleted solid solution along the grain boundaries in the aluminum-copper alloys. However, on page 2 of Naugle's report there occurs this statement, "The transition from the slow speed of intergranular corrosion to the high speed of stress corrosion is brought about by *depletion of material in the grain boundary* ('greater lowering of the grain boundary potential')." The statement is erroneous because Vosskuehler attributes the difference in speed to the effect of stress on a material which is susceptible to intergranular corrosion.

Although Vosskuehler indicates that the grain boundaries of an aluminum-copper alloy susceptible to stress corrosion cracking are probably anodic to the rest of the metal surface, he fails to explain why the grain boundary is anodic when he places so much emphasis on the cathodic nature of the precipitate. Probably this is because he did not measure the potentials of grain boundary regions, and the grain bodies, but measured only the overall potential of the alloys.

Dr. Ulick R. Evans, in his book, "An Introduction to Metallic Corrosion," has attributed an electrochemical theory, substantially the same as the Aluminum Research Laboratories' theory, to Akimow referring specifically to his 1932 paper in *Korrosion Und Metallschutz.* A review of this paper shows no reference to stress corrosion cracking and the most pertinent paragraph dealing with susceptibility to intergranular corrosion follows:

> In a microinvestigation of the corrosion of a 90% Al-10% Cu alloy it was found that the cathodes are formed of the $CuAl_2$ inclusions, since the latter possess a more electropositive potential; the surfaces of the crystallites of the solid solution Al/Cu (the potential of which is very close to the potential of pure aluminum due to a low content) generally represents an adodic field of the alloy. In alloys of three or more constituents, the observed phenomena had to be explained on the basis of the law of a polyelectrode cell.

Although the above, published in 1932, is in accord with the Aluminum Research Laboratories' ideas published in 1928, the location of the most important cathode areas—that is, on the undepleted aluminum-copper solid solution in grain bodies—is completely ignored. The importance of this cathodic area is demonstrated by the fact that an aluminum-copper alloy, artificially aged so as not to be susceptible to intergranular attack or stress corrosion cracking, has copper-aluminum constituent lined up along the grain boundaries as well as in the grain bodies.

The mechanism of stress corrosion cracking is extremely involved, and it is well recognized that although the essentials of the mechanism have been explained in rather simple terms, the relative importance of electrochemical differences caused by metallurgical structure, film-free areas, magnitude of stress, time, and the corrosive environment must vary widely in different metal systems.

The Aluminum Research Laboratories' theory seems to adequately account for the known facts in regard to aluminum alloys. The data necessary to explain the path of fracture in magnesium-aluminum alloys have not yet been obtained nor have the reasons for electrochemical differences known to exist in the metallurgical structure of some metal systems, notably alpha brass, yet been accounted for. It seems fair to state, however, that none of the other theories proposed adequately accounts for these phenomena.

The attempt by McDonald and Waber to emphasize the possible effect of stress in promoting decomposition of metastable phases also fails to account for the unexplained cases. For instance, in alpha brass that is susceptible to stress corrosion cracking, it has been demonstrated that in the absence of stress the grain boundaries are anodic to the grain bodies. Therefore, a phase decomposition produced by stresses that originate at the base of incipient cracks is an unnecessary complication. The conception that incipient cracks form because of surface inhomogeneities and then follow a path definitely related to the metallurgical structure because of the spontaneous decomposition of a metastable phase, appears incongruous. The information needed to complete the explanation of the stress corrosion cracking of alpha brass is an understanding of the cause of the difference in potential between the grains and grain boundaries (the latter being anodic) that have been determined experimentally to exist—to repeat—in the absence of stress.

Mr. Harwood states that the Waber theory has emphasized another possible function of stress, a function that is well supported by much experimental evidence. The evidence given relates to precipitation reactions that are accelerated by cold work. The effects of cold work in accelerating precipitation and on the susceptibility to stress corrosion cracking in aluminum-magnesium alloys were described in the 1940 Institute of Metals Division Lecture (E. H. Dix, Jr., "Acceleration of the Rate of Corrosion by High Constant Stresses," *Transactions*, American Institute of Mining and Metallurgical Engineers, 1940, Vol. 137, p. 11). Cold working also increases the rate of precipitation in certain aluminum-copper alloys, for example, 24S. However, it should be emphasized that cold working rapidly quenched 24S does not promote intergranular corrosion or susceptibility to stress corrosion cracking when the material is maintained at room temperature.

To ascribe the effect of cold working on reaction rates to stress alone is decidedly questionable. Cold working produces dislocations, slip and fragmentation. It is not possible at this time, on the basis of experimental evidence, to separate the relative effect of these changes in structure accompanying deformation from the stress that may result from these changes. An interesting example bearing on this point may be cited. A cold rolled (60% reduction) aluminum alloy containing 5.25% magnesium was exposed at room temperature soon after cold rolling to a 3½% (by weight) sodium chloride solution by alternate immersion for one year stressed to 75% of yield strength without evidence of stress corrosion cracking. After aging without the application of an applied stress at room temperature for four years, specimens of the same material were similarly stressed and exposed. Stress corrosion cracking occurred in an average time of 13 days. In the case of the freshly cold worked material, even with the additional effect of applied stress of 75% of the yield strength, stress corrosion cracking did not occur in one year; whereas, after the cold worked material had aged for four years at room temperature without applied stress, marked susceptibility to stress corrosion cracking developed so that failure occurred in a short time. Although the rate of precipitation was not sufficient to cause stress corrosion cracking during the one year's exposure, the precipitation after four years was sufficient so that the rate of stress corrosion cracking was relatively rapid. Hence, it would seem in this case that the rate of precipitation at room temperature is a slow process compared with the rate of penetration of the stress corrosion crack in material that has developed sufficient precipitate to become susceptible to this type of failure. The above cold rolled alloy was an experimental binary aluminum-base alloy containing magnesium as the alloying element. Commercial alloys of this type in addition to the magnesium also contain manganese and chromium as alloying elements.

Van Wirt (Leland Russel Van Wirt, "The Effect of High Hydrostatic Pressures on Aging," *Transactions*, American Society for Metals, 1935, Vol. 23, p. 633) determined that "... (hydrostatic) pressures of 12,000 atmospheres merely decreased the rate of aging of a number (5) of age hardenable alloys, all of which age at ordinary temperatures," and that, "... the final hardness was not affected by pressure, only the time necessary to attain this hardness; alloys initially but partially aged under high pressures showed no anomalies when the aging was conducted under normal pressures."

That high stresses may accompany internal structural changes has been recognized (E. H. Dix, Jr., "Acceleration of the Rate of Corrosion by High Constant Stresses," *Transactions*, American Institute of

Mining & Metallurgical Engineers, 1940, Vol. 137, p. 11). To quote: "Stresses induced by internal structural changes are a great importance in relation to stress corrosion, especially so because such changes are often localized. When reactions occur at the grain boundaries, high stresses may be induced microscopically in just those locations where corrosion may be greatest because of solution potential differences . . ." In cold preformed material, precipitation occurs on slip planes as well as at the grain boundaries and the same condition of stress probably exists on these planes. Stress corrosion failures of such material often progress along slip planes as well as along grain boundaries."

We must disagree with Mr. Harwood's statement that "for stress corrosion of precipitation systems, the (Waber) theory only differs from the 'depleted zone' theory in the explanation of crack propagation. Whereas the mechanism proposed by Dix and his associates postulates film rupture at the root of the crack, with the filmed matrix-film free metal cell system, electrochemical corrosion . . ." In the first place, the "depleted zone" theory applies only to such systems as aluminum-copper in which the depleted zone is anodic to the precipitated particles and grain bodies containing more copper in solid solution. Although the depleted zone can exist along grain boundaries in the aluminum-magnesium and aluminum-zinc-magnesium alloys, the anodic zones in such alloys are caused by localized precipitated particles. Secondly, in the Aluminum Research Laboratories' electrochemical theory, corrosion starts on the surface because of the difference in electrode potential and not because of surface inhomogeneities of the type supposed by Waber. The path of the stress corrosion crack follows more or less continuous anodic paths preexisting in the metallurgical structure. The effect of film free metal at the base of the progressing crack is to increase the electrode potential difference but is not the controlling factor in determining the path the crack will take.

In conclusion, Mr. Harwood is to be congratulated for his comprehensive treatment of an extremely complicated subject and his impartial presentation of the various theories that have been put forth to aid in the understanding of the mechanism of stress corrosion cracking.

Author's Reply:

The extensive comments of Mssrs. Dix, Brown, and Williams are sincerely appreciated. Limitations of space and the comprehensive nature of the subject prevented a full discussion of the historical background of the various theories discussed in the paper. The comments of Mr. Dix and his associates provide a valuable supplement.

I am certainly in complete agreement that none of the theories which have been postulated to date adequately explain the phenomena of stress-corrosion in all metallic systems. As was mentioned in the paper, our lack of understanding about the mechanisms of stress corrosion in alpha brass, stainless steels and magnesium alloys offers sufficient testimony on that point. There is no inherent reason to believe that any one theory will be adequate to account for the complex phenomena which accompany stress-corrosion cracking in various alloy systems, except from the generalized electrochemical viewpoint. Sufficient evidence exists to show that the propagation of the stress-corrosion crack depends upon the metallurgical state of the alloy, the operative stress-state and the mechanical behavior of the alloy under such a state of stress as well as on the electrochemical characteristics of the "corroding" system.

To those interested in theories of stress-corrosion cracking, I would like to take this opportunity to call attention to a series of most interesting papers[1] which were published in Great Britain subsequent to the preparation of my review. These articles present interesting experimental evidence concerning the mechanical aspects of the stress-corrosion process in the Al-7% Mg and Al-Zn alloys.

1. E. C. W. Perryman and S. E. Hadden, "Stress Corrosion of Al-7% Mg Alloy," *Inst. Metals*, **77**, 207 (1950).
   P. T. Gilbert and S. E. Hadden, "Theory of Mechanism of Stress Corrosion in Al-7% Mg Alloy," *Ibid.*, p. 237.
   E. C. W. Perryman and J. C. Blade, "Relationship Between Aging and Stress-Corrosion Properties of Al-Zn Alloys," *Ibid.*, p. 263.

NACE News

Petition Is Filed for Section at Cincinnati

North East Trustees Meet on February 6

An agenda based on the following points was proposed for the scheduled February 6 meeting of North East Region Board of Trustees at the Atlantic Building, 260 South Broad St., Philadelphia, Pa.: 1) Review of 1950 activity and progress; 2) Aims for 1951; 3) Discussion of section relations; 4) Schedule of Meetings—trustee and joint region-section; 5) Assignment of responsibilities and 6) Status of section rules and regulations.

Bacterial Corrosion Is Topic at New York

Various chemical reactions brought about by sulfate-reducing bacteria in contact with buried or submerged iron were discussed by R. L. Starkey, professor of microbiology at Rutgers University, New Brunswick, N. J., before 65 members and guests of Metropolitan New York Section February 7. "The Role of Bacteria in the Corrosion of Iron," was the topic. Raymond F. Hadley of Susquehanna Pipe Line Co., Philadelphia, who introduced the speaker, briefly reviewed the history of original studies of bacterial corrosion. The discussion following Dr. Starkey's talk brought out some interesting practical experiences encountered in combating corrosion by bacteria.

The newly elected officers assumed their duties. W. F. Fair, chairman, outlined plans for an active membership committee. Kenneth Roll, vice-chairman, submitted details of the program for the April 25 meeting.

Philadelphia Section Hears Two Addresses

Scheduled technical talks at the February 9 dinner meeting of Philadelphia Section were "Chemical Inhibition of Corrosion," by G. E. Best and "Combatting Corrosion with Metal from the Sea," by G. E. Mullin. Mr. Best is technical service engineer for Mutual Chemical Company of America and vice-chairman of Baltimore Section NACE. Mr. Mullin is district chemist for Dowell Inc.

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The Editorial Review Committee of NACE will accept papers about corrosion from reliable sources for review to determine if it be acceptable for publication in CORROSION.

NACE CALENDAR

Mar.

8 Shreveport Section. Caddo Hotel, Shreveport, dinner meeting, "Carbon Rods," by R. L. Westlake, National Carbon Division.

19 St. Louis Section. "The Importance of Inhibited Compounds in the Preservation of Materials Consumed by Corrosion," by A. H. Reynolds, director of product development, Dearborn Chemical Co.

20 Houston Section. Coatings, by George Holm, Tubekote.

20 Chicago Section. "Surface Preparation of Steel Plate," by R. J. Kepfer, E. I. du Pont de Nemours & Co.

21 Corpus Christi Section.

Apr.

5 Houston Section. Graduating students of University of Houston, Rice Institute, Texas A. & M. and University of Texas interested in corrosion to be invited to attend. R. B. Mears, of United States Steel Co., will speak on "The Role of the Corrosion Engineer in Industry."

5 Pittsburgh Section. Program on inhibitors.

12 Shreveport Section.

17 Chicago Section. "The Corrosion Effects of Street De-Icing Salt."

17 Cleveland Section. Dinner meeting.

19 St. Louis Section. "Industrial Application of Aluminum," by Kent R. Van Horn, associate director of research, Aluminum Co. of America. Joint meeting with AIChE and Engineers' Club.

25 Corpus Christi Section.

LYMAN F. GREVE

Lyman F. Greve, about 50, died January 30 at South Shore Hospital, Chicago, Ill., after an illness of several weeks. Mr. Greve, electrolysis engineer for Commonwealth Edison Company of Chicago, was continuously a member of NACE from September 28, 1944. His technical paper, "Corrosion of Underground Power Cable Sheaths," was published in Corrosion in 1948.

Free Reprints Offered On Stress Corrosion

Copies of a reprint are offered by NACE free of cost, postage paid, of Julius J. Harwood's article "The Influence of Stress on Corrosion" reprinted from CORROSION, Vol. 6, No. 8 and 9, 1950. Those interested may secure a copy by addressing a request to Central Office, NACE, 919 Milam Building, Houston 2, Texas.

A petition has been presented asking for authorization of a section of the National Association of Corrosion Engineers for Southwestern Ohio, headquarters probably to be in Cincinnati, although the section is expected to cover Hamilton, Middletown and Dayton. This decision was reached at a meeting January 30 when 38 persons attended an organizational meeting in spite of bad weather and a heavy snow storm. Of this number 17 were members of NACE, it was reported by Lewis M. Lederer, of Inner-Tank Lining Corp., Cincinnati, who has been active in helping organize the section.

The dinner meeting was featured by a round table discussion on the cost of corrosion.

Joseph A. Creevy, Section Chairman, has appointed an executive committee consisting of Milton J. Pfieffer, L. B. Routson, A. F. Thurrell, E. F. Neuzel, Roy O. McDuffie, C. C. Folzenlogan, Robert F. Romell and L. M. Lederer.

Three meetings are scheduled as follows:

March 27—Detailed report of the 1951 Conference and Exhibition to be held in New York. This supper meeting will be at Roselawn Tavern beginning at 6:30 p.m.

April 24—Panel discussion on "Distilleries Process and Corrosion Problems."

May 22—Panel Discussion on Pipe Corrosion.

North Central Officers For 1951 Are Named

Officers for North Central region to take over at once and serve through April 1, 1952 were named as follows by the region nominating committee: Everett Gosnell, vice-president of Colonial Iron Works, Cleveland, chairman; Russell M. Lawall, divisional electrolysis engineer, The American Telephone and Telegraph Company, Cleveland, vice-chairman; Carl E. Heil, president the Heil Process Equipment Corp., Lakewood, Ohio, secretary-treasurer.

A trustee will be named later by letter ballot.

Anderson Talks on Views of Management

H. H. Anderson, vice-president of Shell Pipe Line Corp., Houston, spoke to North Texas Section, on "Corrosion Mitigation Viewed by Management" at an evening dinner meeting held January 29 at the Fort Worth Club, Fort Worth, Texas.

Advance notices of meetings or reports of proceedings will be considered for publication in CORROSION if they pertain to corrosion. CORROSION also publishes notices about corrosion courses held by schools.

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Corrosion in Water Systems Explained At Odessa Session

D. B. Hemphill of Continental Products Co., Odessa, Texas, spoke on "Corrosion in Water Systems" before the January 8 meeting of Permian Basin Section at Gulf Oil Corp. office building, Odessa. He stressed the difference between anodic and cathodic types of inhibitors. Ten members and 12 guests were present.

Officers for the new year were elected as follows: E. B. Ray, Republic Natural Gas Co., Midland, Texas, chairman; E. A. McClendon, Phillips Petroleum Co., Odessa, Texas, first vice-chairman; R. L. Elkins, Shell Oil Co., Midland, Texas, second vice-chairman; C. O. Bundrant, The Western Co., Midland, Texas, secretary-treasurer. W. H. Crenshaw, Cren-Ray Plastic Products Co., Midland, Texas, was named trustee.

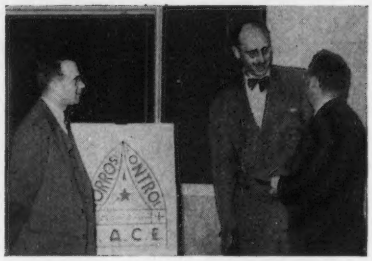
Committee chairmen named were: Program Chairman, Aaron Gensberg, Gulf Oil Co., Odessa; By-Laws Chairman, Tom H. Smith, Odessa American, Odessa; Corrosion Tour Chairman, D. B. Hemphill, Continental Products Co., Odessa.

Regular meeting date of the section is the second Monday monthly.

Hot Dip Galvanizers

The 1951 annual meeting of The American Hot Dip Galvanizers Association will be held at the Biltmore Hotel, Atlanta, Ga. March 21 and 22. Technical papers will be given, a Problems Clinic, discussion of plans for the year ahead and a review of current conditions affecting the galvanizing industry will be on the program. The association also plans to visit the Atlantic Steel Company.

St. Louis Hears Tator On Protective Coatings



G. A. Fisher, program chairman; Kenneth Tator, speaker and F. L. Whitney, section chairman confer during the presentation of Mr. Tator's talk on protective coatings.

Kenneth Tator, chairman of Technical Practices Committee 6 was guest speaker at St. Louis Section's January 15 meeting. His topic was "Protective Coatings and Their Role in Corrosion Control."

He discussed the place and limitations of the four tools of the corrosion engineer: Corrosion resistant metals and alloys, cathodic protection, inhibitors and inert barriers, the latter including protective coatings.

Corrosion resistant organic bases of recent introduction and promising materials now being developed were identified and their probable place in the corrosion protection program indicated.

Three significant trends in corrosion protection by organic coatings and linings were discussed by Mr. Tator in detail. The need for an increasing use of "heavy duty coatings" readily applied in thicknesses ranging from 10 mils to 1/16-inch were described by case histories and slides. The successful experience of several large manufacturers in establishing shops to apply routine maintenance and production linings with their own maintenance departments was illustrated. Methods of simplifying surface preparation requirements for chemical resistant coatings by means of improved wetting characteristics was described.

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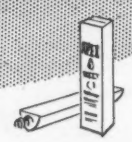

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Cooling Tower Problem Is Discussed at Corpus Christi Meeting

"Cooling Tower Corrosion Problems," was the scheduled topic for discussion by D. R. Baker, Service Engineering Section, Engineering Research Division, Marley Company, Inc., Kansas City, Kans. at the January 24 meeting of Corpus Christi Section. The meeting was announced for the Princess Louise Hotel, dinner to begin at 7:15 p.m.

George Mills also was scheduled to outline plans for the coming South Central Regional meeting to be held at Corpus Christi this fall.

The nominating committee was to submit a report on section officers and the by-laws committee to make suggestions for revision of by-laws.

Mears Will Address Students at Houston Meeting on April 5

R. B. Mears, past president of NACE, 1949 recipient of the Whitney Award for achievement in corrosion science and manager of the research laboratory, United States Steel Company, will address Houston Section members and their engineering student guests at a dinner meeting at New Kaplan's Restaurant, Houston, April 5. His topic will be "The Role of the Corrosion Engineer in Industry."

Graduating and graduate students from the Universities of Houston and Texas, Rice Institute and Texas A. & M. are invited guests.

The meeting is designed to give the guests a better understanding of the problems and duties of corrosion engineers and provide them with an opportunity to talk and meet active members working with problems on the Gulf Coast. Interviews will be arranged between students and representatives of companies engaged in corrosion mitigation work. A fellowship hour with local companies as hosts will precede the dinner and principal address. Plans tentatively call for placement interviews at University of Houston Placement Office and the fellowship hour and dinner meeting at the restaurant.

R. B. MEARS

Members of the steering committee named by Oliver Osborn, section chairman, are as follows: Hospitality, P. P. Spafford; financial, L. C. Tuggle; publicity, J. L. Battle; entertainment, C. W. Scamman; program, C. G. Gribble; arrangements, M. A. Judah, and placement, E. P. Doremus.

Corrosion News Deadline:
10th of Month PRECEDING Date of Issue

Manufacturers of Cooling Towers Are Organized

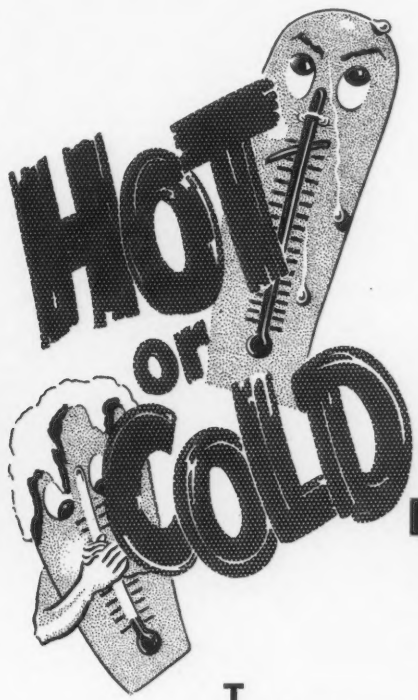
Seven major manufacturers of industrial water cooling equipment have formed the Cooling Tower Institute, with offices at Room 302, LaSalle Bldg., 8 East Ninth Street, Kansas City 6, Mo. The institute's objectives are to develop procedures for improvement in technology, design, performance and testing of water cooling towers.

The institute also proposes to encourage practical measures leading to conservation of water and hopes to interest not only evaporative water cooling but air cooled heat exchanger fields.

Officers elected were: Raymond C. Kelly, president, J. F. Pritchard & Co., Kansas City; J. Robert Fluor, first vice-president, The Fluor Corp., Ltd. Los Angeles, Cal.; John A. Brown, second vice-president, Foster-Wheeler Corp., New York; Leon T. Mart, secretary-treasurer, Lilie-Hoffman Cooling Towers, Inc., St. Louis, Mo.

Mail Embargo Delays Delivery of Corrosion

The post office embargo on second class mail effective February 5 delayed mailing of the February issue of CORROSION five days, with a corresponding delay in delivery and an additional delay resulting from the backlog of mail which flooded into the postoffices when the embargo was lifted.



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An index to the Corrosion Abstracts published during 1950 was published in the December, 1950 issue. The index is a table which gives the month and page number of the topic under which the index is classified.

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TULSA SECTION'S NEW OFFICERS: Seated, L. A. Hugo, chairman, Phillips Petroleum Co., Bartlesville, Okla.; standing, left, T. D. Williamson, Jr., secretary-treasurer, T. D. Williamson, Inc., Tulsa; right, J. N. Hunter, Jr., vice-chairman, Service Pipe Line Co., Tulsa. They took office January 15 at an evening meeting. The program for the meeting included a talk by L. D. Boggs, on "Lami-Rock," a newly-developed plastic pipe.

Engineering Approach To Corrosion Is Topic At Shreveport Meeting

M. L. Bilhartz of Atlantic Refining Co., Dallas, Texas, addressed members of Shreveport Section February 8 at Caddo Hotel Shreveport. His subject was "An Engineering Approach to the Study of Corrosion Problems Encountered in the Oil Producing Industry." There were present 30 members and guests. Mr. Bilhartz gave some statistics on losses from corrosion, including the estimate one cent on every gallon of gasoline refined must be used to pay for the ravages of corrosion. He outlined step by step the procedure recomended for a systematic and sustained corrosion mitigation program.

"Developments in Cathodic Protection" was the topic of an address by W. F. Levert to members of the Shreveport Section NACE at its January 11 meeting at Caddo Hotel, Shreveport, La. Mr. Levert told his listeners something of recent development in cathodic protection technique, including the use of improved backfills for both galvanic and ground bed anodes, the development of magnesium ribbon and others.

Rectifiers of several years ago were compared with those now being produced, the use of galvanic anodes with wind-driven generators, and improvements in gas engine driven generators were mentioned by the speaker. Mr. Levert said improved cathodic protection was the result largely of improved coating practice and better design for ground beds.

R. L. Westlake of National Carbon Division Union Carbide and Carbon Corp. will address Shreveport Section March 8 at Caddo Hotel, Shreveport on "Carbon Rods."

Meetings also have been scheduled by the section for April 12 and May 10, 1951 but programs have not been announced.

Whiteneck Is Elected Western Chairman

L. L. Whiteneck, Long Beach Harbor Dept., Long Beach, Cal. has been elected chairman of Western Region. Also elected by letter ballot were W. M. Schilling, Southern Counties Gas Co., Bell, Cal., vice-chairman and W. E. Kirkendall, Los Angeles Dept. of Water and Power, Los Angeles, secretary-treasurer.

These officers will be installed February 21 at a regional meeting and at the same time nominations for officers of Los Angeles Section will be made for letter balloting.

Corrosion by Dissimilar Pipe Coatings Explained

"Galvanic Corrosion of Interconnected Pipe Lines With Dissimilar Coatings," a paper by David Hendrickson, senior electrical engineer for East Bay Municipal Utility District was the principal item scheduled for a dinner meeting of San Francisco Bay Area Section January 24 at El Jardin Restaurant, San Francisco. Mr. Hendrickson's paper, also scheduled to be given at the NACE Conference in New York, told of corrosion problems incidental to interconnection of aqueducts having dissimilar coatings. Experience with both the Hetch-Hetchy and Mokelumne Aqueducts, with particular emphasis on problems created by interconnected bituminous and concrete coated lines was covered.

James T. Kemp is sceduled to address San Francisco Bay Area Section April 4 at El Jardine Restaurant, San Francisco on "Stress Corrosion Cracking of Copper Base Alloys."

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Building Stone and Masonry Corrosion Is Theme at Salt Lake

"The Disintegration and Corrosion of Building Stones and Masonry" was the topic of an address by Dean Carl J. Christensen of the University of Utah, Department of Metallurgy and Fuel Technology, Salt Lake City before members of Salt Lake Section January 24 at Mountain Fuel Supply Co. auditorium, 36 South State St. The dinner meeting was attended by 13 members and three guests. The dinner was through courtesy of Mountain Fuel and Supply Co.

Nominations for officers of the section were made and following a mail ballot, they will take office at the February meeting.

Dean Christensen spoke of the corrosion of building stones in various parts of the country. Types found in Utah were compared with types found elsewhere as to their life exposed to atmosphere in presence of SO_2 and SO_3. The effects of rainfall, sun and temperature in addition to the corrosive atmosphere also were explained.

Microphotographs permitting comparison of structures and composition were displayed and samples showed effects of exposure to corrosive atmosphere.

NACE Members in Military Service Are Granted Concessions

Members of the National Association of Corrosion Engineers entering military service, may on request, be retained as members of the association in good standing until their return to civilian life, it was dediced December 9 by the association's board of directors at a meeting at Statler Hotel, New York City. The board stipulated their dues while in military service be waived, they would cease receiving Corrosion and there would be no rebate for dues already paid.

Other decisions reached at this meeting included:

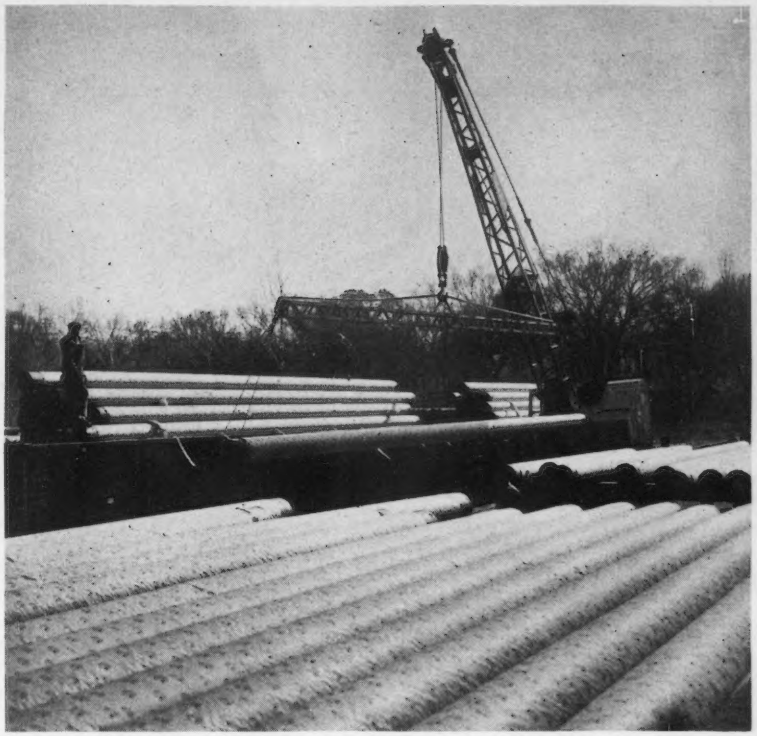
Policy and Planning Committee: Provisions were made for increasing the number on the committee to six and for retiring and electing two members annually.

American Chemical Society: Dr. N. E. Berry was named to represent NACE at the Seventy-Fifth Anniversary meeting of the American Chemical Society in New York City, September 3-7, 1951.

Short Courses: Technical Practices Committees active in the field covered by a short course will be asked to cooperate in promoting the course.

Exhibit Space at Conference: Exhibitors at the 1951 conference will be asked to express their views concerning changes in the method of assigning precedence in the matter of booth space.

International Nickel Co. Research Grant: The International Nickel Co., Inc., while not rejecting a research plan proposed by T. S. Zajac, would prefer the initial research effort be broader and more exploratory, with the implication that if interesting possibilities were uncovered further grants might be expected.



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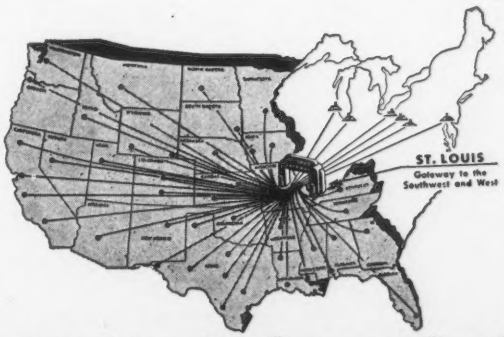

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GREATER NEW YORK COMMITTEE ON ELECTROLYSIS—Shown above at a recent meeting are members of this committee representing railroads, gas and electric utility companies, communications systems and the Municipal Board of Water Supply and New York Port Authority. The committee coordinates underground electrolysis mitigation of various systems in New York. Left to right: Seated, A. E. Archambault, A. M. Schoettgen, M. Bermann, W. S. Woodward, J. Moriarty, J. S. Southwick, F. E. Kulman, A. J. Limata, A. Hagstad, H. F. Koester, C. R. Johnson, L. J. Gorman, R. G. Burdick, C. E. Krutzberg and P. E. Rust; standing, J. R. Recame, G. R. Keltie, F. Cholewinsky, H. W. Dieck, C. H. Platt, E. R. Saul, E. W. Hilbert, D. H. Williams, B. C. Lattin, F. Masin, B. C. Hallowell, W. E. Ripley.

Twenty-Two Organizations Cooperating in Greater New York Committee on Electrolysis

Mitigation of underground electrolysis and corrosion in the New York City area is being accomplished through the cooperation of 22 organizations operating pipe, cable and railroad systems in New York. A group of technical representatives of these firms organized formally June 26, 1947, as the "Greater New York Committee on Electrolysis," is headed by A. E. Archambault of New York Central Railroad.

The committee has held twelve meetings for the exchange of reports and information pertaining to electrolysis conditions arising from the operation of 160 dc railway substations by eight rapid transit systems in the city. A smaller group representing gas utilities recently coordinated plans and specifications for the cathodic protection of the new natural gas main traversing New York. Current problems of committee interest include minimizing the increased corrosion on pipes and cables expected to occur when trolley lines are abandoned. Installations of cathodic protection equipment are being designed to accomplish minimum interference among underground systems.

Although the committee is not affiliated with the National Association of Corrosion Engineers, many of its representatives are members. They are assisting also in planning a cordial welcome for those attending the Annual Conference and Exhibition at Hotel Statler March 13-16.

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ACS Diamond Jubilee Celebration Scheduled

American Chemical Society will hold its diamond jubilee meeting September 3-7, 1951 at New York City. Official greetings from other technical organizations, including NACE, will be tendered the society at a ceremony September 5. Dr. N. E. Berry has been named official representative of NACE.

Twenty technical divisions of the ACS are organizing symposia and sessions of the International Union of Pure and Applied Chemistry and the International Congress of Pure and Applied Chemistry will be held following the society's meeting.

Over 200 Technical Papers Prepared for Petroleum Congress

More than 200 technical papers have been submitted and another 100 have been promised for presentation to the Third World Petroleum Conference, The Hague Scheveningen, Holland, May 28-June 6, 1951.

A permanent council for control of the congresses, including representatives from many of the petroleum producing countries of the world, now is headed by G. A. Tuyl Schuitemaker, of the Netherlands, chairman of the Petroleum Engineering Section of the Royal Netherlands Institution of Engineers and adviser to the Royal Dutch Shell Group. Mr. Schuitemaker succeeds Col. Louis Pineau of France, deceased.

Logan and Uhlig Are Named for NACE Awards

KIRK H. LOGAN

Research Engineer of the Cast Iron Pipe Research Association, Washington, D. C. who has been designated to receive the 1951 Frank Newman Speller Award for contributions to corrosion engineering.

Recipients of the 1951 National Association of Corrosion Engineers' Whitney and Speller Awards have been named as follows by the association's board of directors, following the recommendation of the Awards Committee:

Whitney Award, H. H. Uhlig, in charge of the Corrosion Laboratory at Massachusetts Institute of Technology, Cambridge, Mass.

Speller Award, K. H. Logan, Research Associate of the Cast Iron Pipe Research Association, 1845 47th Place, N. W., Washington, D. C.

The Whitney Award, named for Willis Rodney Whitney, first to receive it in 1947, is given for achievement in the field of corrosion science. The Speller Award, named after Frank Newman Speller, first to receive it in 1947, is for achievement in the field of corrosion engineering. Nominations for the awards are made by the Awards, Certificates and Fellowship Committee of the association. Final approval is by the board of directors. Formal presentation of the awards is made at the annual dinner of the association, to be held this year at New York City.

Others who have received the awards: Whitney Award—1948, Ulick R. Evans; 1949, R. B. Mears; 1950, R. H. Brown. Speller Award—1948, John M. Pearson; 1949, F. L. LaQue; 1950, O. C. Mudd.

HERBERT H. UHLIG

Head of the Corrosion Laboratory, Massachusetts Institute of Technology, Cambridge, Mass. who has been designated to receive the 1951 Willis Rodney Whitney Award for contributions to the science of corrosion.

Award Designees Have Many Corrosion Achievements to Credit

Both men designated to receive the 1951 National Association of Corrosion Engineers' Awards have had extensive experience with corrosion work, a review of their activities reveals.

Kirk H. Logan, designated to receive the Speller Award, was born on a Rice County, Kansas farm January 25, 1879. After graduation from Kansas University in 1902 he taught at Friends University, a small Quaker college in Wichita, Kan. and during the next two years taught physics at Bradley Institute, Peoria, Ill. He then became a student engineer at the Lynn Works of General Electric Co., and the following year traffic engineer for the New York Telephone Co.

For the next four years he taught physics at Kansas A. & M. College, during which and in preceding periods he took graduate work at Brooklyn Polytechnic Institute, The University of Chicago and other schools, receiving an MS degree from KSAC in 1913.

In 1911 he joined the scientific staff of the National Bureau of Standards where he worked on electrolysis problems until 1922 when he organized and directed the bureau's underground corrosion investigations until 1944. During this period he wrote numerous papers on corrosion, including the final report of The American Petroleum Institute's study on pipe coatings. His last work for the bureau was preparation of its Circular C 450 "Soil Corrosion," which summarizes the bureau's underground corrosion work.

Currently as research engineer of The Cast Iron Pipe Research Association he is experimenting with methods of preventing corrosion.

Mr. Logan is married and has four children. He is a Fellow and Life Member of the American Institute of Electrical Engineers, a member of the National Association of Corrosion Engineers since its inception, a member of the Electrochemical Society and several trade organizations. He belongs to the Unitarian church and his chief hobby is restoration of a Virginia mountain farm.

Herbert H. Uhlig started work in the field of corrosion in 1936 as research associate in charge of the Corrosion Laboratory at the Massachusetts Institute of Technology. He was trained as a physical chemist, receiving degrees from Brown University and Massachusetts Institute of Technology. This early research was concerned with pitting of the stainless steels. In 1940 Dr. Uhlig joined the Research Laboratory of the General Electric Company at Schenectady where he continued investigations in corrosion and in related fields concerning properties of metals. In 1946 he returned to Massachusetts Institute of Technology as Associate Professor of Metallurgy in charge of the Corrosion Laboratory.

Dr. Uhlig's interests have dealt with the mechanisms of corrosion reactions and fundamental electrochemistry, with particular emphasis on the nature of passivity, and the chemical and metallurgical behavior of corrosion resistant alloys. He edited the Corrosion Handbook published in 1948, and is currently editor of The Journal of the Electrochemical Society.

He is on the board of directors of the Electrochemical Society, chairman of the Theoretical Division and past chairman of the Corrosion Division. He has also served as chairman of the annual AAAS Corrosion Conferences.

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Ladies' Program for Conference Is Outlined

A special leaflet outlining the entertainment program arranged for ladies at the 1951 NACE Conference to be held at Hotel Statler March 13-16 has been mailed to all NACE members. The leaflet outlines an advance program as follows: Monday, March 12, tea 3:30 p.m. Tuesday: 10:30 a.m. tickets are available for several nationwide broadcast and a private television show, a conducted tour of Radio City. 3:30 p.m. tea at Rainbow Room atop Radio City. Wednesday: Free morning. A fashion show has been arranged at Hotel Pierre, Cotillion Room—luncheon 12:40; show to end at 2:20 p.m. A visit aboard an ocean liner during the afternoon may be arranged. Thursday: 10:00 a.m. bus to United Nations for morning session. Free afternoon.

Many other trips can be arranged on request.

Mrs. Beatrice Bailey of Consolidated Edison Co., New York, is chairman of the ladies committee.

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Subscriptions to CORROSION from nonmembers of the association are accepted. Rates are published on the Contents Page iii.

L. B. Donovan, chairman of the NACE 1951 General Conference Committee, reports that the Technical Program, Exhibition and Local Arrangements Committees have completed all plans to handle what is expected to be a record-breaking attendance by members and guests.

A fine technical program has been assembled by Dr. Norman Hackerman, including several papers recently added as reported elsewhere in this issue.

The Exhibition Committee, of which E. G. Seidel is chairman, reports a new high in both number of exhibitors and number of booth spaces sold, as was indicated by the early receipt of applications.

H. L. Hamilton has had cooperation from his Local Arrangements Committees in preparation for the registration of members and guests, for their entertainment at the Fellowship Hour and the banquet and particularly for the ladies during their stay in New York.

A report on the conference and exhibition will be given in later issues of CORROSION.

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Technical Papers Added To Program Are Listed

Technical papers added to the program for the 1951 Conference and Exhibition of The National Association of Corrosion Engineers to be held March 13-16 at Hotel Statler, New York City, have been given as follows by Norman Hackerman, chairman of the technical program committee:

Protective Coatings Symposium

The Corrosion Resistance of Phenolic and Furfuryl Alcohol Type coatings, by Raymond B. Seymour and Robert H. Steiner, The Atlas Mineral Products Co., Mertztown, Pa.

Chemical Industry Symposium

Passivating Characteristics of Stainless Steel.

Newcomen Medal Is Given to Isaac Harter

Isaac Harter, chairman of the board of Babcock and Wilcox Tube Company, Beaver Falls, Pa., was awarded the Newcomen Medal "for achievement in the field of steam" at a meeting of the Newcomen Society and the Franklin Institute at Philadelphia on January 17. Among achievements of Mr. Harter in steam which led to his nomination for the medal were furthering research to remove diffused oxygen from boiler feed water and the application of this research to boilers into which were built steel tube economizers. This development removed the cause of corrosion which had been preventing the use of steel economizer tubes.

Also attributed to Mr. Harter are assistance in the discovery of the effect of caustic feed water on steel, and the development of improved types of boilers including construction minimizing corrosion from this source.

Program for Voluntary Protection of Technical Information

(Published at request of U. S. Secretary of Commerce.)

Summary

Secretary of Commerce Charles Sawyer has provided a service to help the public guard voluntarily against the harmful release of technical information, even though it is not subject to formal security restrictions.

The office of Technical Services of the United States Department of Commerce will receive requests for advice as to whether specific technical data should be disclosed, withheld, or given limited distribution. OTS will obtain expert opinions from the interested departments and agencies of the Government and inform the inquirer accordingly.

As an industrialist, businessman, scientist, public official, or private citizen, you are invited to use this service whenever you question whether technical information in your possession should be disclosed. It is then entirely up to you whether or not you act on the Government's advice. There is absolutely no compulsion for you to do so, since the program is entirely a voluntary one.

Requests for advice concerning the release of technical information, together with pertinent manuscripts, plans, or documents, if they are available, should be addressed to:

Office of Technical Services,
U. S. Department of Commerce,
Washington 25, D. C.

Your enclosures will be returned with the Government's comment as promptly as compatible with the problems of fact and judgment involved.

Before inquiries are submitted, the information in question should be considered in the light of the types of technical data and the circumstances with which the program of voluntary protection are concerned. These are discussed in the following pages.

The Problem and the Need

The Government is fully aware of the dilemma presented by any limitation, even though voluntary, on the flow of information among private citizens. Free exchange of information contributes to rapid progress in science and industry. On the other hand, all major powers depend on published data for a great share of their strategic intelligence. The present state of emergency, therefore, has directed attention to the security implications of imprudent release of technical information.

The Nation's interests can and should be served by voluntary protection of strategic technical information by private individuals and organizations. The program of voluntary protection is directed toward technical information which, if disclosed, would weaken the total position of the United States more than strengthen it.

What Information Is Affected?

The program of voluntary protection

(Continued on Page 10)

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Program for—

(Continued from Page 9)

is not primarily concerned with information which is "classified" as restricted, confidential, secret, or top secret by the United States Government. Unauthorized disclosures of such information is forbidden under penalty of law. If a question exists whether certain information is classified, however, this OTS service is available to obtain specific advice. The program is primarily concerned with unclassified technical information and industrial and commercial information of a technological nature. Information falling within the scope of the program includes unclassified technical data on:

Advanced industrial developments.
Production "know-how" and technology.
Strategic equipment.
Special installations.

Circumstances in which voluntary protection is invited are somewhat broader than indicated by this listing. The public itself, through inquiries which already have been made of various Federal agencies, has showed its awareness of the dangers of divulging certain information. Those inquiries illustrate certain categories of information regarding which the advice of the Government can prudently be sought:

Collection of Data Which Individually Might Have Little Significance

A major railroad was asked to provide minutely detailed information on the physical lay-out of the system and an analysis of the flow over its lines. The stated purpose of the inquiry was to construct large maps of that and other rail systems. The railroad questioned whether the inquiry should be answered inasmuch as such a set of maps might constitute strategic intelligence of greatest importance.

A major oil company wanted advice on whether to publish a booklet showing the location of its storage facilities throughout the world.

Information Requested Under Unusual or Suspicious Circumstances

A supplier of ordnance received a questionnaire from a broker with respect to his facilities for performing Government contracts. The questionnaire appeared unnecessarily detailed for its stated purpose.

A city official received numerous requests from unknown persons for detailed information concerning fire, police, and water department operations. He felt that such information in the wrong hands might be contrary to national interest.

Technical Information As Yet of Limited General Knowledge

A maker of electronics equipment asked whether a proposed radio broadcast on technological aspects of his products would be a security violation.

Inquiries may also be made on the extent of release which may be desirable. For instance:

Should the information be given only limited distribution?
Should part of it be distributed if part is withheld?
What distribution could be considered prudent?

How the OTS Serves

The Office of Technical Services, John C. Green, Director, was designated by the Secretary of Commerce to serve as a clearing house in the program of voluntary protection of technical information because of its experience in publishing technological information developed in Government agencies or obtained from other countries. For sometime OTS has acted unofficially as a clearing house for miscellaneous requests of the types contemplated under this voluntary program.

In conducting this service, OTS will refer inquiries to one or more agencies expert in the particular field, assemble the comments, and forward the Government's advice together with any original materials submitted by the inquirers. But under no circumstances is a person who requests guidance required to accept the Government's advice regarding disclosure of unclassified information. Each individual possessing knowledge or information is the final judge of how best to serve the public interest.

It will not be possible to provide instantaneous service, but all inquiries will be answered promptly within the limitations imposed by problems of fact and judgment.

Whom the Program Serves

Representatives of private enterprises and other organizations, State and local officials, and private individuals are invited to utilize the OTS service in protecting unclassified technical information.

Regular Contacts

Nothing in this program is meant to stop industrialists and others who have regular contacts in the Government from using their usual channels when questions of security and the public interest arise. The Department of Commerce service, rather, makes it possible for persons who do not have direct contacts to obtain expert guidance from the Government on matters involving strategic technical information.

Scientific and Technical Journals

It is not contemplated that persons in a position to release unclassified technical information will normally call on OTS for guidance regarding release to known representatives of recognized

(Continued on Page 12)

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New Chairmen of TP-16 E and F Named

Chairmanship of one subdivision was vacated by death and two new subdivision chairmen have been added to TP-16 Electrolysis and Corrosion of Cable Sheaths. TP-16A, chairmanship of which was held by the late L. F. Greve, is vacant. New chairmen added are: TP-16E Corrosion and Protection of Pipe-Type Cables, Frank Kahn, Philadelphia Electric Co., 2301 Market St., Philadelphia 3, Pa., and TP-16F Non-Metallic Sheath Coatings, Geo. H. Hunt, Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.

Program for—

(Continued from Page 10)

scientific and technical journals, radio networks, press associations, and newspapers. Most of these organizations have wide experience in safeguarding such material. However, the service will be available to both the editor and the source of the material if they desire to use it.

Export of Technical Data

The program of voluntary protection centering in OTS is concerned with information for release within the United States, which amounts to publication to the world. A separate service for the guidance of persons transmitting unclassified technical information directly to other countries is provided by the Office of International Trade of the Department of Commerce.

A special unit of OIT clears inquiries on the security implications of exporting unclassified technical data on advanced developments, technology, and "know-how"; on prototypes of such developments; on special installations; and on arms, ammunitions, and instruments of war which do not have security classification.

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BOOK REVIEWS

INTERNATIONAL ELECTROTECHNICAL VOCABULARY. Published by International Electrotechnical Commission, 39, route de Malagnou, Geneva, Switzerland. Second Edition, 1950. 8 x 11½ inches, board covers, 311 pages. (No price quoted.)

This edition of the International Electrotechnical Vocabulary is reproduced from the first (1938) edition. It consists of terms and definitions used in the electrical industry, indexed and arranged by groups, with the original vocabulary and definition in French, the second a translation of the French into English and third a corresponding vocabulary in German, Italian, Spanish and Esperanto. Indexes arranged alphabetically at the rear are provided in each of the languages.

Editors of the publication request suggestions for improvement, correction and expansion of the vocabulary and definitions.

Availability of the book is not indicated.

MATERIALS OF CONSTRUCTION FOR CHEMICAL PROCESS INDUSTRIES. James A. Lee. McGraw-Hill Book Information Service, 327 W. 41st Street, New York, N. Y. $6.50.

Over 300 chemicals, combinations of chemicals, food stuffs, pulp and paper, soap, synthetic resins are discussed, with descriptions of processes now in use. Chemicals and products selected cover a wide range of cases where chemical corrosion is important. The chemicals are presented from the standpoints of production, handling and packaging. Emphasis is on materials found practical by experience to be serviceable and economical.

TECHNICAL PUBLICATIONS 1948. Standard Oil Co. (N. J.) and Affiliated Companies. Cloth, 6 x 9, 512 pp. Distribution limited to technical libraries and research organizations.

Twenty-one articles under group headings of Geology and Production, Manufacturing and Fuel Quality, Rubber and Plastics, and Analysis prepared by authors employed by Standard Oil of New Jersey and its affiliates are selected from more than 100 written by technologists of the companies concerned published in scientific journals during 1948 are included. Selection was based largely on whether they contained new information of stimulating nature. Included is "Cathodic Protection of Casings in Loudon Pool," by S. P. Ewing and J. F. Bayhi, which appeared in June, 1948, Corrosion.

Initial distribution of the volume already has been made and it is available in limited quantities only for further dissemination.

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Decisions reached at the August 5 meeting of the National Association of Corrosion Engineers' executive committee have made available free advertising in Corrosion magazine under the headings: Positions Wanted and Positions Available.

Active members may use two consecutive insertions yearly consisting of not more than 35 words set in the standard text type.

Corporate members may use an unlimited number of advertisements consisting of not more than 35 words set in standard text type.

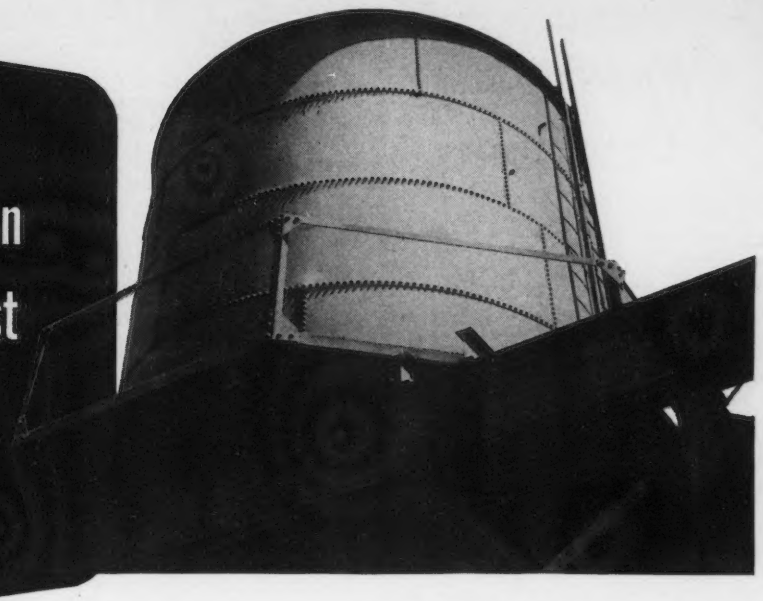
Firms not members but eligible to become corporate members also may use an unlimited number of advertisements consisting of not more than 35 words set in the standard text type.

Individual persons, not members, are not entitled to free advertising on any basis.

Advertisements of any nature or size or frequency which are different from or in excess of 35 words set in standard text type will be charged for at an appropriate rate, the minimum charge being $5.00.

positive corrosion protection at lower yearly cost

WITH PURE METALLIZED ZINC AND ALUMINUM



15,000 gallon sprinkler tank. Interior metallized with .006" pure zinc, in 1934—no trace of corrosion in 1950.

The long-lasting, corrosion resistant qualities of pure metallized zinc and aluminum coatings are well known. Life expectancies for protective coatings of this nature, properly applied, usually range upwards of 20-30 years without further attention.

A new series of 18 basic engineering specifications, called the Metco Systems, recently announced by Metallizing Engineering Co., provide the answer to standardization of surface preparation, coating thickness required for various service conditions, and after-coatings of different materials to meet specific requirements.

The result of over 19 years' continuous testing of pure metallized zinc and aluminum coatings in corrosion protection service, Metco Systems cover the protection of structures and equipment under a wide range of corrosion conditions.

These include actual immersion in salt or fresh water of various pH values; exposure to water ballast, condensate and some mild acid solutions; salt, humid, rural and industrial atmospheres ranging from light to heavy. The Systems also contain provisions for appearance requirements with specific organic coatings, available in a range of colors, all thoroughly tested for compatibility with the metallized zinc or aluminum.

The following organizations are set up to provide positive corrosion protection at lower annual cost in accordance with Metco* System specifications. For further information, or a copy of descriptive bulletin, contact the one nearest you.

**Reg. U. S. Pat. Off.—Property of Metallizing Engineering Co., Inc.*

Metco System contractors

Akron Sand Blast Co. 50 E. Springfield Rd. Barberton, Ohio Tel. Plaza 3412	**Dix Engineering Co., Inc.** 1417 Dix Road Lincoln Park 25 (Detroit), Mich. Tel. Dunkirk 1-8822	**Metal-Cladding, Inc.** Lakeview & Porter Avenues Buffalo 1, N. Y. Tel. Elmwood 9536
Metalweld, Inc. Fox & Hunting Park Ave. Philadelphia 29, Pa. Tel. Radcliff 5-3471	**Nooter Corporation** 1420 South Second Street St. Louis, Missouri Tel. Main 6000	**Thermaflo Metal Products, Inc.** 50 Dell Avenue New London, Conn. Tel. 2-4300	**Arthur Tickle Engineering Works, Inc.** 21 Delevan Street Brooklyn, N. Y. Tel. Main 5-4200

Clippings on Corrosion

Extracted from Current Periodicals

FARMERS WARNED NOT TO USE SALT AS ANTI-FREEZE

Daniel Kitchen, University of Nebraska extension agricultural engineer warned farmers corrosion resulting from the use of calcium chloride anti-freeze can do as much damage to a tractor engine as freezing the block.

•

ALL-WELDED ALUMINUM TORPEDO BOAT LAUNCHED

(From Baltimore, Md., Evening Sun, Nov. 28, 1950)

Annapolis, Nov. 28—The Navy's first all-welded aluminum patrol torpedo boat will be launched here Thursday. Forerunner of the new class replacing World War II patrol torpedo boats it will be christened USS PT-811. Three aluminum sister vessels have been built at shipyards in Philadelphia, New London, Conn. and Bath, Maine, but the hulls were not of the all-welded type.

•

CIVIL AIRCRAFT MAKERS ASK MATERIALS PRIORITY

(From New York Times, Dec. 7, 1950)

Shortage items facing one of the largest manufacturers of civil aircraft stood at 100 sixty days ago but now amount to about 350. Defense order rating priorities for such items as corrosion-resistant steel parts for power plants, landing gears, gear boxes and mechanical actuators are needed if line stoppages are not to occur in 30 days.

•

METHOD OF COATING WITH MOLYBDENUM IS DESCRIBED

(From Baltimore, Md., *Evening Sun,* January 5, 1951.)

W. J. Childs of Lafayette College, Easton, Pa., J. E. Cline and W. M. Kisner and John Wulff of MIT, Cambridge, Mass., told members of the American Society for Metals at Chicago molybdenum-coated articles may be used as substitutes for those made wholly of the metal. Coating of the metal on other metals by reduction of molybdenum pentachloride vapor was discussed by the scientists.

•

LEAVES MAY CORRODE

(From Idaho Falls, *Idaho Farmer,* Nov. 10, 1950.)

Leaves left in roof gutters produce acid when standing in water which corrodes metal.

•

BATTERY CORROSION PAINT INVENTED IN DALLAS

(From Dallas, Texas, *Dallas,* Nov. 30, 1950)

A paint-like chemical compound to limit corrosion resulting from batteries has been developed by L. D. Carroll, who retired from battery manufacture and entered Southern Methodist University at 60 to gain sufficient knowledge of industrial chemistry to complete the formula. The material known as "Sheeld" is being produced by Sterling Industries and marketed by Newman Associates, both of Dallas, Texas.

•

CORROSION-RESISTANT BARN EXHAUST FANS RECOMMEDED

(From Williamsport, Pa., *Gazette & Bulletin,* December 21, 1950)

Blades of fans used to provide forced ventilation for dairy barns should be made of corrosion resistant material which can be cleaned easily when necessary. Control by a corrosion resistant thermostat also is recommended.

•

DEFOLIANTS MAY CORRODE EQUIPMENT, FARMERS WARNED

(From Tucson, Ariz., *Star,* Nov. 3, 1951)

Leaf-removing chemicals or defoliants vary in their corrosive action on equipment, J. N. Roney, entomologist for the agricultural extension service at University of Arizona warned. All equipment used for distribution of defoliants should be cleaned thoroughly before using for other purposes, he said.

•

HEMPHILL TALKS ON WATER SYSTEM CORROSION

(From Midland, Texas, *Reporter-Telegram,* Jan 7, 1951)

Dan Hemphill of Continental Products Corp., Odessa, was the scheduled guest speaker Monday before a meeting of Permian Basin Section NACE, in Odessa. His topic was corrosion in water systems. Officers were scheduled to be elected.

•

PARAFFIN SUGGESTED TO PROTECT SALT SHAKER

(From Pueblo, Col., *Chieftain,* Dec. 23, 1950)

Metal tops of salt shakers can be protected from corrosion by covering the inside of the tops with paraffin and while the paraffin is hot, the holes may be opened with a toothpick.

•

WASH CARS TO STOP SALT CORROSION ENGINEER SAYS

(From New York City, *New York Times,* Jan. 21, 1951)

Ralph Wirshing, chief of General Motors Research Laboratories, discussing damage to car bodies from salt used to melt road ice, said panels from car bodies exposed in winter temperatures ranging from those prevalent in Detroit to those common in Florida, were sprayed with a 5 percent salt solution and with other salt solutions containing various inhibitors. No difference in the rate of corrosion was noted, he reported.

Mr. Wirshing also contends side effects from use of inhibitors, such as toxicity of chromium compounds which may injure the feet of pets and persons allergic to the materials, must be considered.

Frequent washing is the recommended protection against salt damage, in addition to repainting places where abrasion exposes metal.

GRIP-TITE STEARNS
Pipe Line Anchor Assembly

PROTECTS PIPE COATING!

See Our Booth No. 17 at Corrosion Conference.

Originated and designed especially for *protection to pipe coating,* Grip-Tite Anchors with Stearns Pipe Saddle make positive Permanent hold-downs for all kinds of pipe line construction through marshy, swamp or flooded lands. They eliminate the need of cast iron or concrete weights, save time, money and handling expense. They're field proved beyond any doubt!

For detailed information write

GRIP-TITE MANUFACTURING COMPANY

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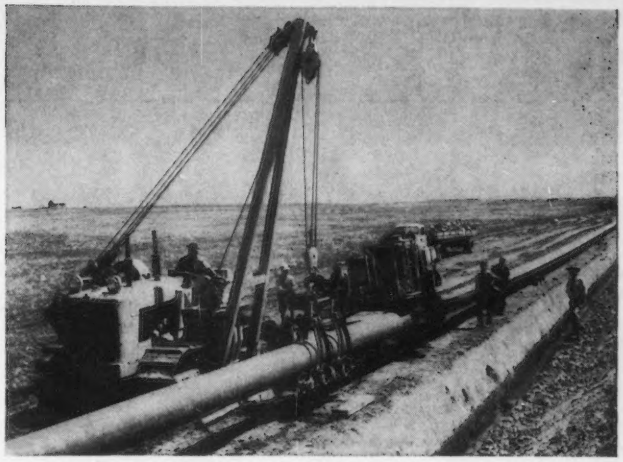
MEMBERSHIP CARDS AVAILABLE

Association members in good standing will be issued on request a membership card in the National Association of Corrosion Engineers. Address requests to A. B. Campbell, Executive Secretary, 919 Milam Building, Houston 2, Texas.

Canada's GIANT NEW PIPE LINE...



▲ Koppers Bitumastic Enamel being machine-applied.

▼ When completed, this giant line of the Interprovincial Pipe Line Company will carry oil from Edmonton, Alberta, to Winnipeg, Regina and tankers on the Great Lakes. It will require 64,330,000 gallons of oil to fill this line.

protected by KOPPERS BITUMASTIC ENAMEL

● From one end to the other, the new 1,150-mile line of the Interprovincial Pipe Line Company will be protected against corrosion by Koppers Bitumastic® 70-B Free-Flowing Enamel. This giant outlet will carry the production of Alberta's oil fields to Winnipeg, Regina and Ontario markets.

Koppers Bitumastic 70-B Enamel, machine-applied over a coat of Koppers Bitumastic 70-B Priming Solution, will protect 450 miles of 20″ pipe, 340 miles of 16″ pipe, and 360 miles of 18″ pipe. Highly-corrosive soils, river crossings, cold weather—all types of rugged conditions—will test the effectiveness of the protective coating.

Many of America's pioneer oil and gas pipe lines—laid in the twenties—are still giving good service today, thanks to the effective protection of Koppers Bitumastic Enamels. And hundreds of applications of Koppers Bitumastic Enamels have given Koppers engineers unequalled experience in pipe-line protection—experience that can help you.

Give your pipe lines *assured* protection against corrosion by specifying "Koppers Bitumastic Enamel." Get in touch with your Koppers representative for complete details and estimates.

Why Bitumastic Enamels give lasting protection

Processed from a base of coal-tar pitch, they are impervious to moisture . . . chemically resistant to soil elements. They make a tight bond with the pipe . . . do not disintegrate with age . . . maintain continuously high electrical resistance.

KOPPERS BITUMASTIC ENAMELS
REG. U.S. PAT. OFF.

KOPPERS COMPANY, INC., Tar Products Division, Dept. 304T, Pittsburgh 19, Pa.

NEW PRODUCTS – Materials – Service – Literature

Agava Boiler Conditioner, a compound in which extracts of tropical plants are used is recommended by the manufacturers, Agava Products, Inc., 34 Exchange Place, Jersey City, N. J. as a rust and corrosion preventive. The company claims also the compound removes scale, impurities and oil from boilers. Action of the material is attributed to its adsorbtive properties, its faculty of keeping impurities in suspension and its ability to absorb impurities. Agava Cooling Water Conditioner has the same anti-corrosion properties as the boiler conditioner, the company says, and in addition is toxic to algae and slime-forming organisms without being harmful to human skin.

•

Acme Steel Company has been licensed by United States Steel Company to manufacturer "Cor-ten," low alloy steel developed by Carnegie-Illinois Steel Corp.

•

Carpenter Steel Co., Reading, Pa. will build a $3,000,000 hot rolling mill, a combination of strip, bar and rod mill designed and engineered to provide the company's specialty production of tool, stainless and alloy steels. The company also has started production of Carpenter Alloys B and C (Hastelloy) tubing and pipe to handle oxidizing and reducing corrodents. Sizes being made are from 5/8-inch through 4½-inch, full finished with weld bead removed. Information on these new products can be secured from the Alloy Tube Division, Union, N. J.

•

Jennite J-16 surface seal, a proprietary compound, is recommended by Manufacturers Maintenance, Inc., Wooster, Ohio for application to most materials to act as a barrier to water, cold, sunlight, heat, sugars, fats, fungus, open chain solvents, mineral oils and acids, inorganic salts and chemical fumes. No flow point at any temperature is claimed for the material.

•

Corexit, new Humble Oil & Refining Co. corrosion inhibitor, a non-toxic, free-flowing liquid with very little odor is recommended for injection in oil wells where sulfide corrosion has resulted in tube leaks and rod failures. A technical paper "A New Inhibitor for Sulfide Corrosion," by J. A. Caldwell, of Humble Oil and Refining Co., P. O. Box 2180, Houston 1, Texas, gives details, including economic aspects of treatment of several wells. Bar graphs give information on inhibitive effects on flow-line coupons and rod breaks.

•

Rubber now may be bonded to metals directly without the necessity of providing a brass interlayer, according to Natural Rubber Bureau, Washington, D. C. The so-called "Redux" process consists of treating the vulcanized rubber surface to be bonded with concentrated sulfuric acid for about 4 minutes, washing with water and drying. The acidized surface then is coated with a thin coat of "Redux" liquid resin. The degreased, shot-blasted or chemically cleaned metal surface also is given a thin coat of "Redux." The coated surfaces then are dipped in "Redux" powder after which they are clamped together at 50 lb. sq. in. and stoved at 140 degrees for 20 minutes. The same method permits bonding natural rubber to Bakelite, Tufnol, Delaron and similar materials. Copies of the issue of "Rubber Developments" in which the process is described may be obtained from the Natural Rubber Bureau, Dept. 1, 1631 K Street, N. W., Washington, D. C.

•

An improved hand serrating tool to be used in assuring tight workmanlike joints in Karkate impervious graphite pipe is now being made. Catalog Section S-7060, describing the tool and its uses may be secured from National Carbon Division, Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y.

•

Penfield Water Demineralizers are described in a portfolio "Penfield Pays" which contains sheets each of which gives the characteristics and capacity of a Penfield ion exchange of synthetic resin demineralizer. Water analysis is essential to determination of the correct demineralizer so the company offers to give an analysis to interested firms which send in a quart of their water. More information about these devices may be secured by writing Penfield Manufacturing Co., 19 High School Ave., Meriden, Conn.

•

Baking and Air Drying Implement Enamels, Technical Bulletin No. 28 gives technical information on this class of coating and Metal-Furniture Air-Drying Enamels, Technical Bulletin No. 29, gives technical information on that class. These bulletins may be secured from American Cyanamid Co., Coating Resins Dept., 30 Rockefeller Plaza, New York 20, N. Y.

•

A Slide-Rule Type data sheet which gives the characteristics of Carpenter Stainless Steels from Blanking, Punching and Perforating through Welding, is being offered by the company from its Reading, Pa., office. The characteristics are listed in columns on a cardboard slide section, which, when moved back and forth between the outer covers, positions the data in a window. Printed vertically beside the window is a list of Carpenter Steels by brand name with their related AISI Type numbers so that the various characteristics of the steels may be brought successively into juxtaposition with the steels. The reverse side of the mechanism is identical except the workability data, including such things as hardening and quenching temperatures, corrosion resistance, intergranular corrosion, etc., is printed beside the window and the data on the slide is specific for the various Carpenter steels. This side also includes references on general corrosion resistance. The reverse side includes a standard analysis table.

PERSONALS

Charles W. Fredenburg, is now with Industrial Materials Company, 5424 West Chicago Ave., Chicago 51, Ill. The company specializes in contract application of technical coatings in the Middle West.

•

Gaudreau, Rimbach and Associates, 921 Ridge Ave., Pittsburgh 12, Pa., consulting engineers, with offices in Pittsburgh, Chicago, New York and Washington has been organized. Richard Rimbach, a member of the firm is a member of NACE.

•

Frank A. Watts, sales manager for Humble Oil & Refining Co. has been named director of the Materials Division of the Petroleum Administration for Defense. He served in a similar capacity from December 1942 through April, 1944.

•

Eagle Supply Co., Fairfield, Ill., has moved to new quarters at 106 N. E. Second St. Chet G. Maguire is owner and general manager.

•

Outdoor Floodlights for industrial use made of die-cast aluminum alloys are manufactured by Stone Manufacturing Co., Elizabeth 4, N. J.

•

William G. Gerstacker has been named chief engineer of The Colonial Iron Works Co., Cleveland, Ohio.

•

Donald F. Deakin has joined Atlas Mineral Products Co., Mertztown, Pa., as water and sewer products director and **Newton O. Duncan, Jr.,** has been assigned to the Houston, Texas office.

•

Howard N. Verrault has been assigned to the Dampney Company's Chicago office as branch manager.

•

Kenneth G. Compton, with Bell Laboratories, Murray Hill, N. J., is recuperating from an illness at home.

FREE ***Preprints and Reprints While Supply Lasts***

Corrosion Problems Related to Air Transport Aircraft, **by Otto E. Kirchner and Fred M. Morris, American Airlines. A paper prepared for presentation at NACE meeting, St. Louis, Mo., April, 1950.**

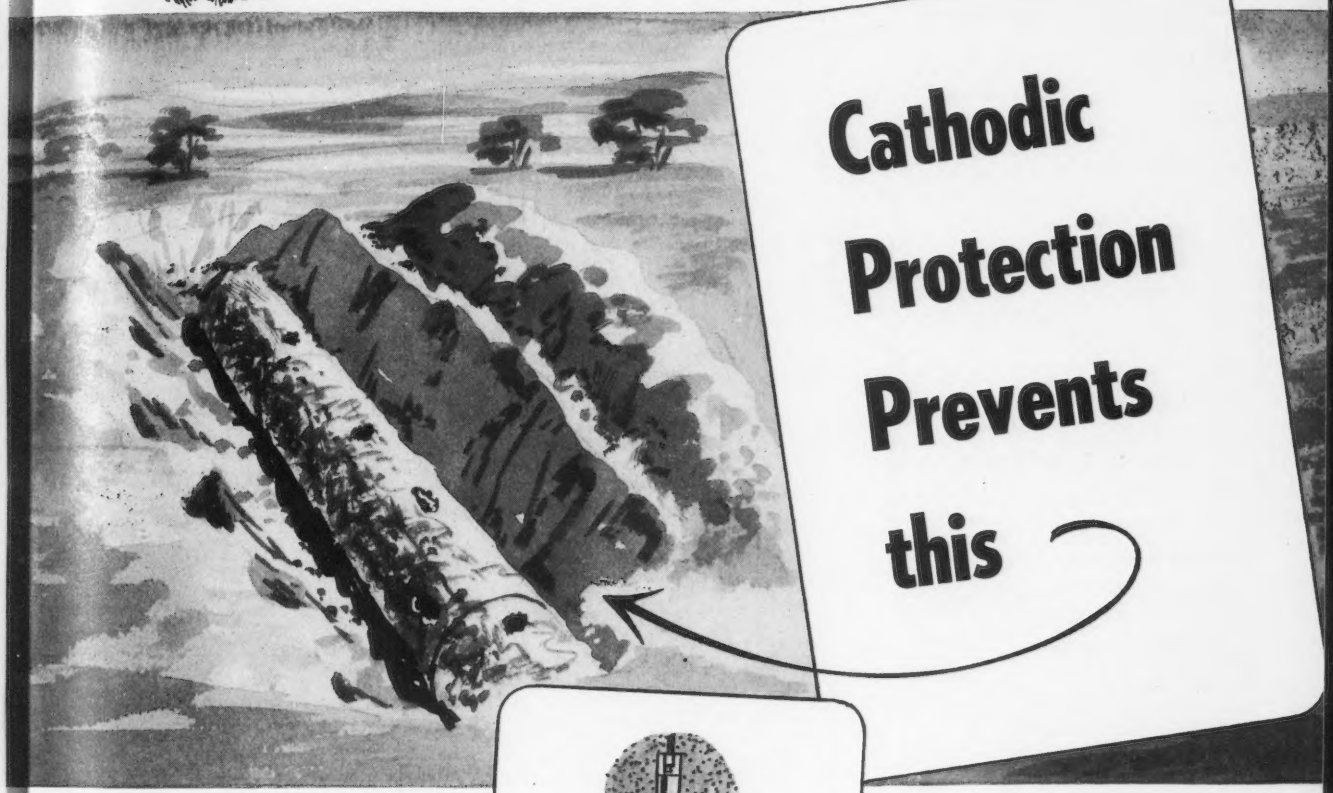
The Influence of Stress on Corrosion, **by Julius J. Harwood, Office of Naval Research, Washington, D. C. Reprinted from CORROSION, Vol. 6, No. 8 and and 9 (1950). A paper presented at the NACE meeting, St. Louis, Mo., April, 1950.**

Address your request to: Norman E. Hamner, Managing Editor, Corrosion, 919 Milam Bldg., Houston 2, Texas.

Whoooooo ...

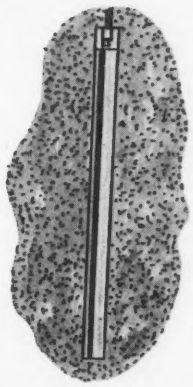
needs Cathodic Protection?

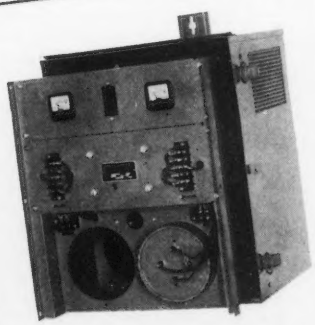
Yooooooo!



Cathodic Protection Prevents this

NATIONAL CARBON
ground anodes for long life
and dependability





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√ Oil immersed with no oil to carry

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We Offer . . .

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I A GUARANTEED maintenance program on tanks and steel structures wherein a pre-determined cost extending over 9 or 12 years, averaging 4 cents per year, per square foot can be properly budgeted.

II TANK LINING service with fully proven protective linings for **Sour Crude, Acid Sludge, Run Down, Acid Storage, Caustic Storage and Floating Roof Tanks.**

III EFFECTIVE, and fully proven service on LINING **Tubular Goods, Treaters and Wash Tanks. Salt Water Disposal Pipe, Drill Tubing.**

IV PIPE LINES, exterior for protection from exposure over **Salt Marshes and Swamps, and from Ground Acids.**

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We invite your inquiry on corrosion problems. They will be given prompt and courteous attention.

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PROVEN CHEMICAL RESISTANT LININGS to Fit the Job!

For TANKS, VESSELS, PIPE, Etc.

SELECTED FOR Long Life AND TROUBLE-FREE SERVICE

LOOK INTO Heil LININGS

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•HEILEX •LEAD
•SPECIAL METALS

Heil PROCESS EQUIPMENT CORPORATION CLEVELAND 11, OHIO

Corrosion Problems

Questions and answers for this heading should be submitted in duplicate if possible, addressed to "CORROSION PROBLEMS", National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Questions received at the address above above will be sent to E. A. Tice, The International Nickel Co., Inc., N. Y., who is acting editor of the page. All questions will become property of NACE. Questions and replies may or may not be published under this heading and may be answered either by mail directly to the person asking the information, or published under this heading, or both, at the discretion of the editorial staff. Answers to published questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous if they request it.

NEW QUESTIONS

No. 75—The question is relative to the corrosion phenomena of deep well turbine pumps where the water pumped is fairly corrosive. The chemical analysis of the water in question is as follows:

pH	7.3	
Sediment	667	mg/liter
(CO_2)	28.9	" "
(O_2)	4.1	" "
(Cl)	200.6	" "
(SO_4)	48.4	" "
(S) Sulphide	0.3	" "
(HCO_3)	334.8	" "
(SIO_2)	18.8	" "
(Al_2O_3)	2.6	" "
(CaO)	120.3	" "
(MgO)	75.9	" "

The turbine pumps which are of sizes varying from 10" to 18" are installed in steel castings just big enough to accommodate the turbine pumps. The depth of the bore-holes varies between 30 and 100 metres. Very serious corrosion trouble has been experienced in the past in this pumping area. Any suggestion put forward for the application of cathodic protection would be appreciated. References to papers or data relative to similar problems would be welcome.

No. 76—In connection with the atmospheric corrosion resistance of zinc coated sheet steel is there any evidence available as to whether a hot dipped coating will last longer than an electroplated coating of the same thickness? One theory has been stated that when the zinc coating corrodes down to the zinc-iron alloy layer on hot dipped sheet this layer corrodes at a lower rate than the zinc itself. Consequently, the hot dipped coating could be expected to last longer. If this is true, proportionally how much longer life can be expected?

QUESTION

No. 64—(As revised in December, 1950, issue) We should like to line a large steel hot water generator which is to operate under constant heat between 160 and 212° F. A permanent lining which can be applied in the field is desired.

ANSWER C

This is in reply to both this question and Question 72 which was of a similar nature. Although we have not conducted tests in distilled water at elevated temperatures our regular "Phenoline" and modified "Phenoline No. 2" might offer possibilities of working. Both are quite expensive. Regular Phenoline requires a primer, but the modified Phenoline No. 2 does not, and is satisfactory for temperatures up to 240° F.

"Carbo-Kote 6020," reinforced with a fiberglass membrane has performed satisfactorily in 210° F. 5 percent sulfuric acid solutions. It has also performed satisfactorily in tapwater at 212° F. In this latter service the dimensions of the samples did not change, the physical appearance of the samples did not change, and there was no change in the color of the water after a 14-day test.

We would certainly like to cooperate with the individual submitting this question.—Stanley L. Lopata, Carboline Company, St. Louis, Missouri.

QUESTION

No. 68—In regard to the problems of impingement attack at the inlet ends of condenser tubes:

a) Is there a coating material which can be applied to the affected region at yearly intervals to overcome the attack?

b) Do plastic inserts eliminate the trouble or merely displace the impingement attack to a location beyond the insert?

c) Does the practice of smoothing out the ridge between the rolled and unrolled part of the tube have merit?

ANSWER

There is available a protective coating material called "Debecote" designed specifically to solve the problem of impingement attack at the inlet ends of condenser tubes. This product has been used for over twenty years in a great many condensers and similar service throughout the country with excellent results. It is easily applied by brush or spray using two or three coats depending upon the service. Full information regarding this special coating can be obtained from the Debevoise Company, 968 Grand Street, Brooklyn 6, New York.—Douglas B. Blackburn, The Debevoise Company.

Mallinckrodt Chemical Works, Second and Mallinckrodt St., St. Louis 7, Mo. has issued an illustrated chart depicting the history of chemistry from its origins in China, India and Egypt, up to the present. Copies may be obtained from Joseph Fistere, president.

Notice to Authors of Technical Material in Corrosion

For a handling charge of $5 the National Association of Corrosion Engineers will ship postage paid to authors of technical material published in CORROSION, not earlier than six months after publication, printing plates used for figures in articles, NACE undertakes to ship such printing plates as are available, without warranty as to their condition or completeness. Those who wish to take advantage of this offer are asked to submit a request in writing, giving the issue in which the article in question was published, full address to which plates are to be shipped and billing information to:

NORMAN E. HAMNER,
Managing Editor, CORROSION,
919 Milam Building,
Houston 2, Texas

Corrosion Abstracts

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Vol. 7 March, 1951 No. 3

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(Complete Topical Index used for Corrosion Abstracts may be found in FIVE YEAR INDEX TO TECHNICAL ARTICLES, Corrosion, December, 1950.)

*** PAGINATION OF CORROSION ABSTRACTS**

Two numbers appear on each page of Corrosion Abstracts. The number in the upper outer corner is for page sequence within the issue only. The number in the lower outer corner, which is followed by the letter "a," denoting "abstracts," is for the convenience of those who bind Corrosion Abstracts by volumes. Because both numbers appear on each page and because it is believed indexing by the volume serial number will be more useful, effective with this issue the "Index to Corrosion Abstracts" will be keyed to the number found in the lower outer corner of each page followed by the letter "a."

GENERAL

• Miscellaneous

1.1

The Corrosion of Metals. W. H. J. Vernon. *Journal of the Birmingham Metallurgical Society*, **29**, 131-152 (1949) Sept.

Surveys economics, theory, testing, and prevention. 41 ref.—BLR.

1.1

What You Should Know About Corrosion of Ferrous Metals. From data presented before AISI, 6th Regional Technical Mtg., San Francisco, Nov. 10, 1949. *Steel*, **126**, No. 11, 101-102 (1950) Mar. 13.

Classes of corrosion discussed include atmospheric, bacterial, chemical, high temperature oxidation, soil, stray current electrolysis and underwater. Question of reversal between steel and Zn is also discussed. Graphs are given on effects of temperature, bicarbonate, sulfate, and chloride.—INCO.

1.1

Improved Plating and Corrosion Protection to Result from New Developments Revealed at Electrochemical Society Meetings. *Steel*, 125, 82-85, 117-118, 120 (1949) Nov. 21.

Presents extended abstracts of a number of papers presented at 96th annual meeting, Oct. 12-15, 1949. X-ray method for determining thickness of tin coating on steel; recent advances in tin, chromium, and alloy plating; and various corrosion processes were among the topics. —BLR.

• Reviews

1.3, 3.5, 5.9

A Review of the Electrochemistry of Stressed Metals. M. T. Simnad. *J. Electrochem, Soc.*, **97**, p. 31C-44C (1950) Feb.

Critically surveys published work on the above under the headings: origin and nature of internal stresses; latent energy in deformed metals; influence of stress on electrode potential and corrosion rate; effect of surface preparation on corrosion; stress corrosion of ferrous and non ferrous metals; corrosion fatigue; and internal stresses in electrodeposited metals. 256 ref.—BLR.

1.3, 1.8

Recent Developments in the Electrochemistry of Metallic Surfaces. (In German.) K. Wickert. *Archiv fur Metallkunde*, **3**, 346-353 (1949) Oct.

Surveys recent literature on chemical and electrochemical corrosion, discussing the various theories. 36 ref.—BLR.

• Books

1.6, 3.7

Metals Reference Book. Edited by Colin J. Smithells. Roy. 8vo. Pp xvi+735, illustrated. 1949. London: Butterworths Scientific Publications. (60s.)

Under the editor, Dr. C. J. Smithells, his assistant editors, and contributors, both a comprehensive and a realistic treatment is to be expected, and is found. Perhaps no better illustration of this realistic outlook can be given than the very first section, which deals, and deals quite well, with the sort of first-aid which might be required in a metallurgical laboratory.

Twenty-five pages of the mathematical formulae likely to be of use to the metallurgist, including 381 intergrals, will be found of immense assistance to those of us whose equipment in this direction leaves much to be desired. It is an interesting commentary on the revolutionary change which is taking place in metallurgical analysis that no less than 52 pages are devoted to the spectrographic characteristics of the metal and the use of these for analytical purposes. The same point is again brought out towards the end of the book, when a small, but adequate, section is devoted to polarography. As would be expected, X-ray crystallography is dealt with at length,

PRIMARY SOURCES OF ABSTRACTS PUBLISHED IN CORROSION

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.
ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Onatrio, Canada.
AWWA—Journal, American Water Works Association. Amer. Water Works Assoc., 500 5th Ave., New York 18, N. Y.
BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.
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BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.
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ME—Marine Engineering, The Institute of Marine Engineers. 85/88 The Minories, London E. C. 3, England.
MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.
NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.
NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.
PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.
RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.
RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.
RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.
TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.
TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.
UOP—Universal Oil Products. 310 South Michigan Ave., Chicago, Illinois.
ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

together with the crystallography and "crystal chemistry" of the metals and their more important compounds. To the metallographer, the pages devoted to metallographic techniques, among which perhaps electrolytic polishing and etching may be specially mentioned, will be found of the greatest interest. One hundred and seven pages are devoted to the binary, ternary, and the beginnings of the quaternary thermal equilibrium diagrams. In some cases these are on a somewhat small scale, but are sufficiently clear to stand enlargement under a lens, and it is of the greatest assistance to have them collected together.

Gas-metal systems and diffusion are then considered, and as indicating the solidity of the treatment, 63 references to the former and 231 to the latter are given. It may be stressed here that, throughout the book, the treatment is nowhere superficial and provides both the information and the background which are essential. Thermal, thermoelectric, electrical, and magnetic properties are next dealt with, the 20 pages devoted to the last being particularly good.

The second half of the volume starts with a consideration of mechanical testing and mechanical properties. Lubrication, foundry data, fluxes, contraction allowances, moulding sands, and refractory materials are then considered, followed by data referring to fuels. An extremely interesting chapter deals with the chemistry of controlled atmospheres for heat-treatment processes, which, within the limits of space available, is excellent. Corrosion electroplating and finishing, welding, soldering, and brazing complete the book except for an index, which, so far as the writer has been able to observe, is both adequate and accurate.—MA.

• Organized Studies of Corrosion

1.7, 4.6

Kure Beach Begins Its Fifteenth Year. International Nickel Company. *INCO*, **23**, No. 3, 4-7 (1949).

The corrosion testing Station at Kure Beach, near Wilmington, North Carolina, operated by International Nickel Co. with some support from others, has now been in operation for 15 years for the study of the behavior of materials in salt water service. The present article is a brief popular illustrated note on operations.—BNF.

1.7

Recent Progress in Corrosion and Microbiological Corrosion Research at the Chemical Research Laboratory, D.S.I.R. (Teddington). W. H. J. Vernon. *Metaux et Corrosion*, **23**, No. 270, 34-40 (1948).

A general account of the work being carried out at the Chemical Research Laboratory on accelerated corrosion testing, potential measurements of painted steel (on immersion), corrosion inhibitors (sodium benzoate), stripping the protective films from stainless steels and microbiological aspects of soil corrosion. —MA.

• Fundamentals

1.8

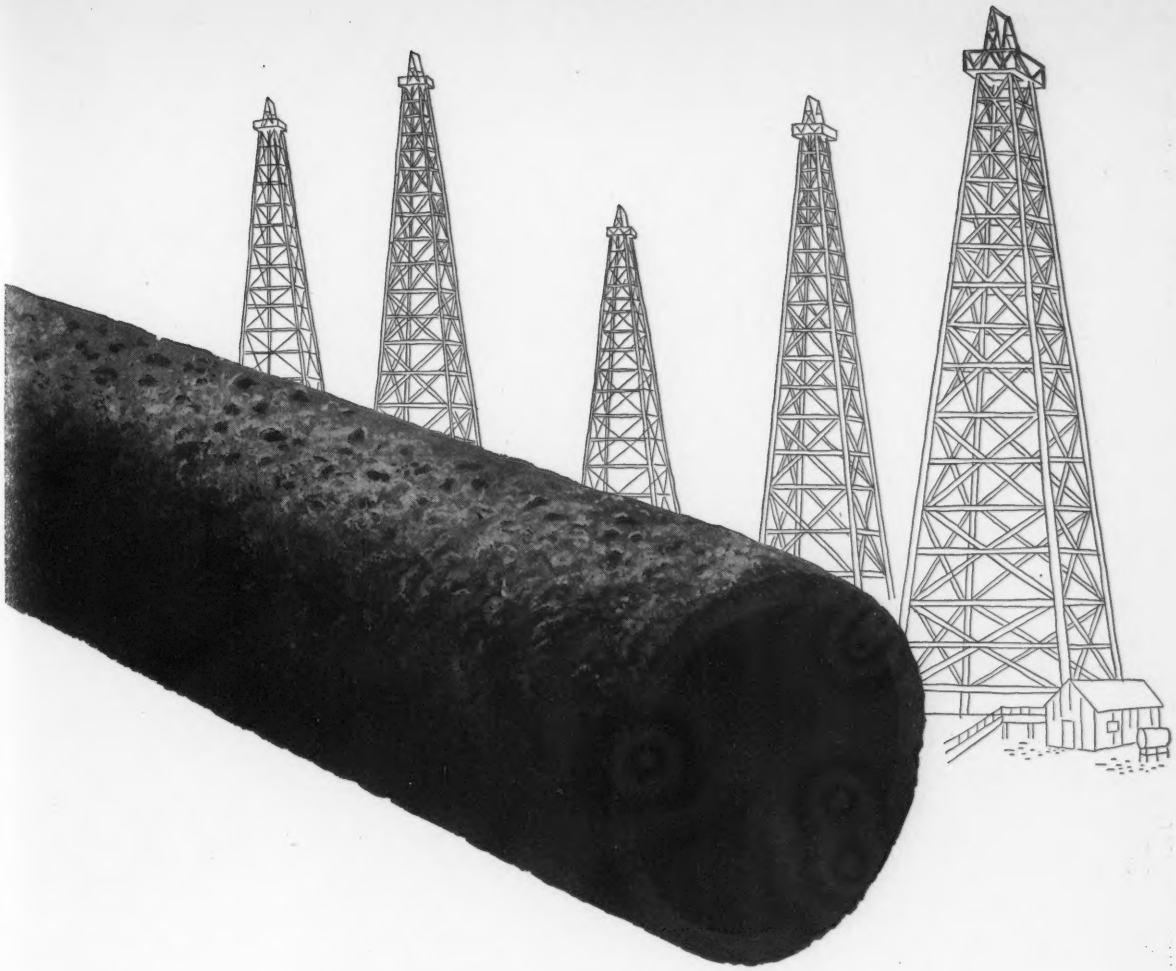
The Rehbinder Effect. E. N. da C. Andrade and R. F. Y. Randall. *Nature*, **164**, 1127 (1949) Dec. 31.

Rehbinder and colleagues have reported that surface-active liquids in contact with the surface of metals, in particular of single crystals, markedly diminish mechanical strength. However, Kemsley obtained negative results with single crystals of tin. Outlines experiments which seem to indicate that the Rehbinder effect is due to a disintegrating action of the agent on the oxide film, which in its original condition strengthens the crystal, and not to any deep penetration of the liquid as supposed by Rehbinder.—BLR.

1.8, 6.5

Progress in the Study of the Surface Oxidation of Metals and Alloys at High Temperatures; I—Introduction; II—Rapidity of Oxide Film Formation; III — Study by Electron Diffraction at High Temperatures of Oxide Films Formed on Fe, Co, Ni, Cr, Fe-Cr 13%, and Stainless 18-8 Steel. E. A. Gulbransen. *Revue de Metallurgie* (France), **45**, No. 7, 181-204 (1948) July.

Increasing interest has been shown in the fundamental study of kinetics and constitutional factors which are active in the formation of thin oxide films on metals and alloys. The experimental methods used in the study of the reaction of surface oxidation are presented, along with results. A complete study of the reaction of oxidation which takes place on metals and alloys acknowledges the correlation of numerous variable factors such as time, temperature, pressure, gaseous compositions, etc. . . . with the fine structure of the metal and the oxide



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film. Three structural factors are important for such a correlation: 1) the structural network or the geometric arrangement of atoms, ions or molecules in the film; 2) the primary structure which shows the size and the form of crystallites in the oxide film; 3) the secondary sturcture which shows the size and form of particles (agglomerated crystals) and the nature of the limit regions between particles, as well as other physical details of structure in the film. Other important factors exist for a complete study of the reaction of oxidation; 1) the atomic composition of the film; 2) the presence of defects and impurities in the network; 3) the nature of diffusion methods of metal ions or of oxygen ions in the oxide film.

A complete analysis of the oxidation reaction following the above plan is a complex problem and has many experimental difficulties. Considering the actual experimental techniques and the development of new techniques, the following factors are evaluated carefully: 1) the method must permit an almost continuous study of the reaction on a scale of time, temperature, and pressure; 2) sufficient sensitiveness must be obtained for a study of the region where the film is thin, and the region of temperature in which the metal or alloy is a protective underlying layer; 3) the results obtained must give results which are reliable with a minimum of hypotheses.

The oxidation reaction has been studied by the following experimental techniques, which are discussed in detail: 1) the microbalance in a vacuum for the study of rate of reaction; 2) in an electron diffraction chamber for the study of crystalline networks and the primary structure of the oxide film; 3) by the electron microscope for the study of primary and secondary structure of the oxide film; 3) by spectrographic analysis to identify the presence of several atom constituents in the oxide film.

In the study of the rate of the formation of oxide films a weight gaining method is used in which a microbalance of sensitive quartz is placed in a vacuum. This method permits a continuous study of the oxidation reaction through a large range of pressure and temperature. This method and the results obtained are discussed with graphs and tables.

The improvement of the electron diffraction chamber has furnished a new instrument for the study of the reticular structure of thin oxide films. This method also gives preliminary information on the primary structure of these oxide films. Single relatively thick films can be studied by X-ray diffraction analysis and chemical analysis. Chemical analysis gives information on the percentages of different atom species present in the film, while the X-ray diffraction method gives geometric atom information. In certain cases the information obtained can be identical, but in general these two points of view are necessary. Many of the first experiments were carried out by oxidizing large samples and permitting thick films to remain on them. The products were identified, after cooling to room temperature, by X-ray diffraction and chemical analysis. These studies give little useful information on the character of the protective films during the time when these films were really protective. More fruitful studies by electron diffraction have been made while using the reflection technique, in which the reaction takes place at high temperatures systematically. To perfect the electron diffraction chamber and auxiliary accessories, the conditions of time, temperature and pressure during oxidation must be determined. This permits the establishment of a direct correlation with the measures of rapidity. The apparatus is described and illustrated, together with graphs and tables of results.

1.8

Local Element Effect and the Solution of Iron. (In German.) F. Todt. *Archiv fur Metallkunde*, **3**, 353-354 (1949) Oct.

Briefly discusses Wickert's criticism of Evans' theory of corrosion and criticizes Wickert's test procedure and theory.—BLR.

1.8

Passivity in Chromium—Iron Alloys: Adsorbed Iron Films on Chromium. Herbert H. Uhlig. *Trans. AIMME*, **175**, 710-719; discussion, 719-727 (1948).—MA.

PREVENTIVE MEASURES

• Non-Metallic Coatings and Paints

5.4, 6.4

Some Experiments on the Painting of Aluminum Alloys. W. A. Edwards. *Light Metals*, **12**, 626-632 (1949) Nov.

Presents results showing effect of type of paint and of type of alloy, intrinsic corrosion resistance of various aluminum alloys, effect of alloy variation on coating performance, performance of different finishes, and finishes for marine conditions. Includes tables.—BLR.

5.4, 6.7

The Outlook for Ceramics in Gas Turbines. W. H. Duckworth and I. E. Campbell, Battelle Memorial Inst. *Mech. Eng.*, **72**, 128-130 (1950) Feb.

Investigations pertinent to gas turbines have been rather thorough on most of the refractory oxides singly, and on many combinations of oxides. Ceramic bodies were evaluated for use in rotor blades, stator blades, combustion chambers, and ceramic coatings. With lower mechanical requirements stator blades offer a more likely future for ceramic bodies than rotor blades. Ductility is necessary in the combustion-chamber liners of present designs — eliminating direct substitution of ceramic bodies for the sheet metal now used. Coatings for metals seem particularly attractive for immediate use, while ceramic bodies might afford more outstanding benefits. With close cooperation between ceramists and gas-turbine engineers it is expected that gas turbines with higher operating temperatures, longer life, or both, and, perhaps, lower weight may be produced.—TDD.

5.4

New Corrosion Resisting Resin Coatings. *Elec. Eng.*, **68**, No. 11, 32 A (1949) Nov.

B. Resin Solution is made for application at room temperature, requires no mixing, and is flexible when dry. Chief advantages over the polyvinyl chloride and chlorinated rubber coatings are: resistance to acids of higher concentrations, resistance to higher liquid temperatures, and resistance to solvents such as alcohols and straight chain chlorinated and aromatic hydrocarbons. Developed by Brooklyn Polytechnic Institute in conjunction with Carboline Corp. —INCO.

5.4

Rust Preventive. *Eng. News-Record*, **143**, No. 26, 62 (1949) Dec. 29.

Rustarest No. 30 can be used on aluminum, chromium, and ferrous or nonferrous metals. It produces a hard, tough coating but is pliable enough to take bending and curving. Mfd. by Internat. Rustproof Corp.—INCO.

5.4, 8.8

Corrosion-Resistant Materials: Some Newer Materials in the Plating Industry. V. Evans. *Ind. Fin.* (Lond.), **2**, No. 16, 184-186 (1949).

A survey of the uses and properties of chemically resistant asphalt (flame-gun applied) for the exterior protection of pickling and plating tanks; Polythene, Perspex, plasticized and unplasticized polyvinylchloride, butyl rubber, and polyisobutylene for interior protection, sulfur and synthetic-resin cements for chemical brickwork; and Polythene, polyvinylchloride pastes, and vinyl copolymer pastes for plating-jig protection.—MA.

5.4, 3.3, 2.2

Problems in Fungus and Moisture Deterioration. W. N. Ezekiel. Dept. of the Navy. *Electrical Manufacturing*, **45**, No. 3, 78-85 (1950) Mar.

The study of deterioration caused by fungi and moisture has led to new concepts of engineering design starting at the level of materials, components, subassemblies, and protective measures. Protection against fungus and moisture should be considered routine in all design and the methods developed by the armed services can be applied to many "civilian" products. Some of the wartime and postwar experiences with fungus and moisture deterioration in the United States, or in nontropical combat areas, are cited. Results of tests with extruded nylon for hook-up wire are discussed. Fungistatic coating materials, i.e., suitable varnishes and lacquers, were selected which are based on good electrical properties, such as a high dielectric value (even when wet), good compatibility with the various materials used in electrical equipment, and high adherent properties. Fungistatic chemicals were incorporated into these coatings so that fungus growth will be discouraged on the surfaces and also on dust particles over the surfaces. Field exposure tests were made on a series of varnishes, lacquers and wax solutions, each varying in fungistatic values, as well as a group of plain (nonfungistatic) coatings. Some typical results for observation after three months are compiled. The terminology used and a classification of some materials for moisture and fungus proofing are given. Specifications and applications of some special fungistatic coatings used by the Bureau of Ordnance are tabulated.—TDD.

5.4

Industrial Protective Organic Coatings. H. W. Foelsch, Stalpic Coatings Co. Paper before Am. Pulp & Paper Mill Superintendents Assn., Northwestern Div., Fall Mtg., *Duluth Paper Trade J.*, **129**, No. 25, 30-31 (1949) Dec. 22.

Results of an extensive test program on the thermoplastic type of resin in-

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5.4

Silicone Surface Coatings. M. H. Glaser, Midland Industrial Finishes Co. *Prod. Eng.*, **21**, No. 2, 109-111 (1950) Feb.

Modified silicone resins offer improved properties including superior stability when exposed to heat, moisture and electrical forces. The silicone finishes are aluminum pigmented silicone paints. Charts of physical and chemical properties of finishes are given and also one of the ratio of gloss retention to hours of exposure at 400° F.—INCO.

• Surface Treatment

5.9, 5.4

Prevention of Metallic Corrosion. *Machinery Lloyd*, **21**, No. 11, 94-97 (1949). *J. Inst. Metals & Metall. Abs.*, **17**, Pt. 5, 360 (1950) Jan.

The various coatings available for protective treatments have been subdivided by the Ministry of Supply into nine possible classifications. Phosphating and chromating are pre-eminent for preparing Zn, Al, and Mg surfaces before painting. A phosphate coat followed by a chromate coat forms an ideal initial treatment where severe service conditions are to be expected. Figures are given to show the rapid build-up in corrosion resistance with the use of double and even treble phosphating (Walterization) treatments. Advantages, method of using, and other possible applications are given.—INCO.

5.9, 6.3

Conversion Coatings on Zinc. Vincent Mattacotti. *Prod. Fin.*, **14**, 52-54 (1950) Feb.

Surveys various methods for the above. Tabulates and discusses results of salt-spray tests.—BLR.

5.9, 6.4

Cleaning, Etching, Chemical Polishing, and Brightening of Aluminum. Walter R. Meyer and Steven H. Brown. *Proc. Amer. Electroplaters' Soc.*, **36**, 163-188 (1949); discussion, 189-191.

Cleaning methods for aluminum are briefly reviewed, and the results of some experiments are presented on the inhibiting effect of sodium silicate with a mole ratio of 1 : 3.32 on the dissolution of aluminum by solutions containing 5, 15, 30, and 69 g/l NaOH. In order for attack to be substantially prevented, it is necessary for the final weight ratio $Na_2O : SiO_2$ in the solution to be $|>$ 1.5 : 1, and it is better if it is $|>$ 1 : 1, especially with cast alloys, which, in most cases, are more susceptible to attack than the commercial-purity aluminum on which the experiments were carried out. The effect of oxidizing agents on the rate of attack by a solution containing 4 oz./U.S. gal. NaOH at 82° C was studied, and it was shown that most oxidizing agents increase the rate of attack. 4 oz./U.S. gal. of the strongest oxidizing agent used, sodium chloride, doubled the rate. Methods of acid dipping and smut removal are summarized. Some experiments are described which show the effect of the method of surface treatment on the electrode potential of aluminum. It is concluded that the solution activity of commercial-purity aluminum in a highly corrosive medium (53 g/l NaCl and 3 g/l H_2O_2) is not affected by nitric acid pretreatment and, in general, that solution potentials do not vary with time. Using a Na_2SO_4 electrolyte, a nitric acid treatment ennobled some materials but not others such as Duralumin. Single-dip immersions in sodium zincate solution produced surfaces which had approx. the same solution potentials as various prepared zinc surfaces except on Duralumin, which was only slightly activated. A comparison is made of the dissolution rates of wrought aluminum alloys in acid etching and acid polishing solutions, and there are some notes on the commercial application of chemical polishing. 11 references are appended.—MA.

5.9, 6.3

Pickling of Nickel and High-Nickel Alloys. *Metal Treatment and Drop Forging*, **16**, 183-188 (1949) Autumn.

Discusses composition of solutions suitable for pickling various high-Ni alloys. Cleaning and degreasing treatments are described and various dip and paste pickle solutions are suggested for removal of tarnishes, thick scales, and thin oxide films associated with different alloys. Importance of the absence of iron is emphasized and methods described for its detection and removal.—BLR.

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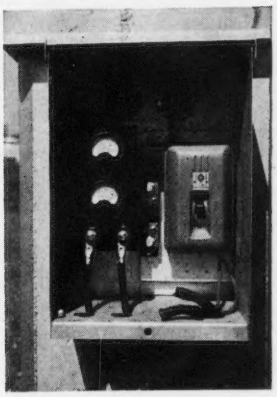
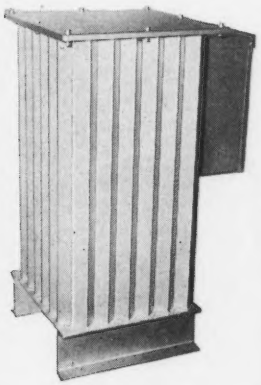


Oil-immersed, selenium rectifier —field installation showing meter and terminal box.



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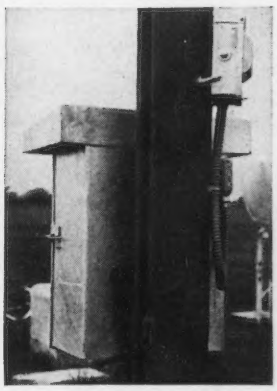

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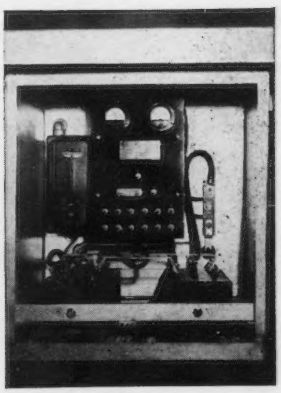

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5.9, 6.2

Brush Finishing for Appearance and Corrosion Resistance. R. O. Peterson, Osborn Mfg. Co. *Sheet Metal Worker,* **41,** No. 3, 42-43 (1949) Dec.

Brushing methods are very satisfactory for finishing stainless steel. Their ability to supplement the action of long used polishing or buffing tools in production of surfaces suitable for plating and to provide possibility of considerable cost saving are important factors responsible for increasing popularity of brushes as finishing tools. Different types of brushes are explained. By use of brushes defects are readily seen.—INCO.

5.9, 6.4

Chromate Finish Gives Corrosion Resistance to Aluminum. *American Machinist,* **94,** No. 6, 156 (1950) March 20.

Iridite Alcote, a chromate corrosion-resistant finish for aluminum, is applied by non-electrolytic dip with the solution operating at room temperature. No fumes are given off during the process. Coatings range in color from clear to light bronze. For greatest color intensity and optimum corrosion resistance, immersion time of 2 minutes is recommended. Salt-spray tests are reported to indicate resistance to corrosion for as long as 1000 hr. on wrought stock and 250 hr. for castings. Announced by Allied Research Products Inc.—INCO.

5.9

Tentative (ASTM) Specifications for Chromate Finishes on Electrodeposited Zinc-, Hot-Dipped Galvanized, and Zinc-Die-Cast Surfaces (B201-49T).

ASTM Specifications and Tests for Electrodeposited Metallic Coatings, **1949,** 22-23.—MA.

5.9

Symposium on Surface Treatment of Metals. I. Electrodeposited Metals. (4) Physical and Engineering Properties of Electrodeposits. J. S. Anderson. Australian Inst. Metals, Melbourne Branch, Phys. Met. Div. Preprint, **1949,** 8 pp.

The engineering properties and applications of electrodeposited metals are reviewed. Physical properties of electrodeposited metals are, in most cases, similar to the same metal in massive form, but there are exceptions which are important in engineering design, notably porous chromium. Specialized applications, such as electroforming, plating on non-conductors, and plating and diffusion as applied to bearings are discussed. Some modern trends, including bright plating and periodic reverse-current plating, are mentioned. The need for improved technical knowledge and control in the electroplating industry in Australia is stressed. A bibliography of 18 references is appended.—MA.

5.9, 6.4, 4.6

Process Sheet for Dichromate Treatment of Magnesium. G. Black. Reference Book Sheet. *Am. Machinist,* **92,** No. 10, 135 (1948) May 6.

Dichromate treatment for magnesium alloys is used where high resistance to salt water corrosion is desired. The steps for the process are outlined.—INCO.

5.9

Cleaning Aluminum Sheet Prior to Spot Welding (I-II). Gerald H. Boss. *Metal Prog.,* **55,** No. 4, 499-503; No. 5, 668-673, 1949.

A diagram is given of an apparatus developed for measuring the contact resistance at aluminum sheet surfaces. Experiments show that cleaning processes leading to a surface resistance of less than 50 or 60 microhms are satisfactory; the surface resistance of uncleaned sheets is 700-1200 microhms. A proprietary cleaner, "Oakite 84A," is said to give excellent results in deoxidizing aluminum surfaces as judged by contact resistance. $NaHSO_4$ solution held at 180° ± 10° F (82° ± 5.5°C), also give good results when a wetting agent is present. Chemical degreasing solutions containing Na_3PO_4 or Na_2CO_3 or both, plus some soluble silicate, gave satisfactory results. Many chemical mixtures were tested for deoxidation of the surface after degreasing; these included chromates, fluorides, phosphates, fluoborates and hydrofluosilicic acid solution; these were all for operation at room temp. Among the larger U. S. aircraft companies, hydrofluosilicic acid was often used. The final rinse water must be closely controlled and the cleaned sheets allowed to dry in warm air: they must not be wiped.—MA.

5.9, 4.3

Salt-Bath Chromizing. J. E. Campbell, V. D. Barth, R. F. Hoeckelman, and B. W. Gonser. *J. Electrochem. Soc.,* **96,** No. 4, 262-273 (1949).

Steel parts are immersed in a fused salt bath containing: chromous chloride 30, barium chloride 40, sodium chloride 21%, and with sufficient chromium flake to cover the bottom of the vessel. An

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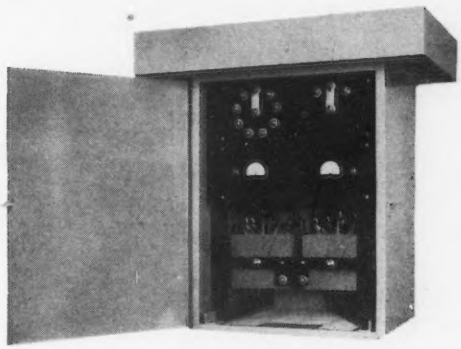

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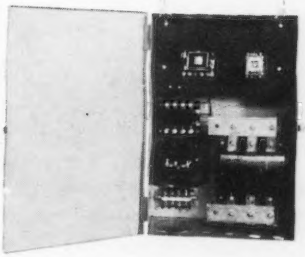

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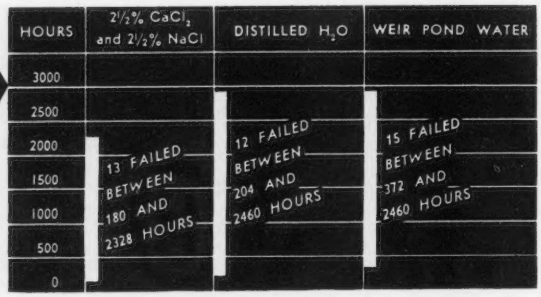

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argon atmosphere is used to exclude air. A table is presented indicating the temp. to be used for various steels. Nickel, molybdenum and tungsten have also been treated. Specimens produced could be immersed in HNO_3 (1.2 sp. gr.) for 3-4 months without effect, provided the case was not porous and was reasonably thick—above 0.0002 in. Curves are presented showing the effect of time and temp. on the thickness of the case. The advantages of this method over the usual one is that there is greater latitude in chromous chloride concentration, elimination of packing and unloading operations, furnace heating and cooling, and the possibility of chromizing simultaneously articles requiring different periods of treatment. 16 references are appended.—MA.

MATERIALS OF CONSTRUCTION

• Non-Ferrous Metals and Alloys—Heavy

6.3, 4.2

Properties (and Corrosion-Resistance) of Wrought Commercially Pure Titanium Prepared by Arc Melting and Casting. C. I. Bradford, J. P. Catlin, and E. L. Wemple. *Metal Prog.*, **55**, No. 3, 348-350 (1949).

The mechanical properties and corrosion performance are discussed. 20% cold work raises the 0.2% yield strength from about 74,000 to 100,000 lb./in.;² at 50% cold work the elongation is still 12%. The metal is notable for its strength properties up to 800° F (427° C), being about twice as strong at this temp. as is the strongest aluminum alloy at 400° F (204° C). Over the range room temp. to 800° F, the Young's modulus remains practically const. Sheet with an ultimate strength of 130,000 lb./in.² showed a fatigue limit of 55,000 lb./in.² At 800° F and under a stress of 16,000 lb./in.² the average rate of creep was 0.000015% per hr. over a period of 1125 hr. The machinability is similar to that of austenitic stainless steels; it may be spot, seam, and inert-arc welded. Titanium is completely resistant to marine corrosion and is in the same class as platinum. A considerable range of possible applications is indicated.—MA.

6.3

Some Effects of Heating Zirconium in Air, Oxygen, and Nitrogen. E. T. Hayes and A. H. Roberson. *J. Electrochem. Soc.*, **96**, No. 3, 142-151 (1949).

Experimental work to determine the practical limits to which zirconium can be heated in air are described. The data presented apply to only one type of zirconium with one type of surface finish, and no control of grain-size was attempted. Insufficient information was obtained to ascertain diffusion rates of oxygen and nitrogen in the metal, or to present equations expressing the amount of oxygen that will be absorbed under a given set of conditions. Permissible times of heating are set out for various temp. ranging from 425° to 1300° C, based on a weight gain of 600 mg/dm,² and on metallographic evidence of penetration of oxygen and nitrogen into the metal. Absorption of nitrogen by zirconium is much slower than absorption of oxygen. There is a marked increase in

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penetration of oxygen at about 900° C and of nitrogen just above 1000° C. This is probably associated with the allotropic transformation which takes place at 862° C. Dense zirconium may be heated to almost 1000° C in dry oxygen without burning. The possibilities of obtaining hard surface coatings are considered, and it is shown that surface hardness values of about Knoop 900 (Rockwell C 65) can be obtained by heating in dry air, oxygen, or nitrogen at the appropriate temp. Although the oxide coatings may have definite uses, the nitride coatings have the disadvantage of breaking down when heated in air and producing a voluminous mass of oxide.—MA.

• Non-Ferrous Metals and Alloys—Light

6.4, 2.2

Several Cases of Protection (of Aluminum Alloys) and of Assemblies of Aluminum Alloys (and Steel) and Their Endurance in a Sea-Water Spray. Nicholas Beliaeff. *Metaux et Corrosion,* **24,** No. 290, 239-245 (1949).

B. describes the results of corrosion tests made on a) clad Duralumin sheets of various origins, b) aluminum-5% magnesium alloy sheet anodically treated in various baths, c) aluminum-5% magnesium, and aluminum-4% copper alloy sheet painted with anti-fouling paint, d) assemblies consisting of steel bolted or screwed to various aluminum alloys. The specimens were either immersed in or exposed to spray from the Mediterranean Sea for periods of up to 26 months. Details of the mean atmospheric temp. and humidity and of the salinity of the sea are given. Mechanical tests were carried out on some of the specimens before and after exposure. The results show: 1) that the corrosion-resistance of clad Duralumin sheet is greatly dependent on the coating thickness; where this is 5% or more of the total thickness (1 mm) corrosion-resistance is high, but where the coating is only 3% of the total thickness the sheet is attacked rapidly; 2) sheet anodized in a bath of sodium bisulphate (20%) resists attack at least as well as sheet anodized by the usual sulphuric acid process; 3) the use of anti-fouling paints containing copper and mercury salts is dangerous with aluminum-5% magnesium alloys, but has no effect on Duralumin-type alloys; 4) aluminum-magnesium alloys give the best results in steel-aluminum assemblies; the life of these assemblies depends upon the aluminum being insulated from the steel. Anodic oxidation is inadequate for this purpose, and a suitable paint must be used; especial care must be taken in painting bolted assemblies owing to the ease with which penetration of the corrosive medium occurs.—MA.

6.4

How to Avoid Watermarks on Aluminum. G. W. Birdsall. *Steel,* **124,** No. 9, 86, 88 (1949).

Aluminum sheets and products allowed to become wet during storage are liable to be surface stained by the action of chemicals normally present in water. Methods of protection are: 1) ensuring that the metal is initially dry; 2) storage in a dry atmosphere away from possible water drips or condensation; 3) stacking in such a way that the material can readily dry out should it become wetted. Storage of aluminum on the ground should be avoided. The stains can be removed by a) practically any of the commercial etching compounds, at the expense of a superficial attack over the entire area, b) a slight etch in warm caustic solution, or c) mechanical abrasion.—MA.

6.4, 3.2, 3.7

Corrosion-Resistant Aluminum-Magnesium Alloys. P. Brenner, Gt. Brit. Royal Aircraft Establishment, Farnborough, and W. Roth, High Duty Alloys, Ltd., Redditch, Eng. *Engineering,* **166,** 44-47 (1948) July.

The close relation between the microstructure and the susceptibility to intercrystalline corrosion and stress corrosion of aluminum-magnesium alloys was confirmed in several experimental series. The microstructure depends largely upon the heat treatment applied. The most pronounced changes occur in water-quenched alloys during aging up to 300° C. Water quenching from the homogenizing temperature results in maximum supersaturation of the alloy. The decomposition of the solid solution progresses gradually with increasing aging temperature. Low aging temperatures induce precipitation at the grain boundaries resulting in a fine continuous network which corresponds to a minimum of stress-corrosion resistance. High aging temperatures coagulate the precipitate at the grain boundaries, and also precipitate fine, randomly distributed particles within the grains, thus leading to a network of coarser, isolated particles corresponding to an increase in stress-corrosion resistance.

Air cooling or interval cooling results in a microstructure of more or less fine, separate particles and in fair resistance to stress corrosion. Aging at elevated temperatures, however, causes further precipitation of the magnesium held in solid solution and results in a continuous network with correspondingly reduced stress-corrosion resistance. Extremely slow furnace cooling, at a rate of 50° C per hr. from the homogenizing temperature, precipitates all the magnesium in excess of that in solid solution at room temperature. The resulting structure has high stress-corrosion resistance and is stable up to 100-150° C since no further precipitation can occur.

The mechanism of attack of aluminum-magnesium alloys by intercrystalline and stress corrosion can be explained by considering that the precipitated Al_3Mg_2 phase is anodic to both aluminum and the solid solution. The current density and therefore the corrosion rate increases with a decrease in the anodic: cathodic area. Very fine grain-boundary precipitation, therefore, increases intercrystalline penetration, whereas additional precipitation within the grains reduces it. When the condition of homogeneous precipitation is approached, the selective attack changes into a more general type of corrosion.

Aluminum-magnesium alloys containing small additions of manganese, zinc, or chromium show a substantial improvement in stress-corrosion resistance, especially after furnace cooling. This has not yet been explained but corresponds with a marked change in microstructure. Since the mechanical properties of these alloys are practically independent of the thermal treatment, it is possible to select a heat treatment to improve the corrosion resistance.—PDA.

6.4

Gas in Aluminum and Its Alloys. (In French.) R. Castro and M. Armand. *Revue de Metallurgie,* **46,** 594-616 (1949) Sept.

Presents critical survey of the literature with emphasis on the Al-H_2 system. The subject is treated under the following headings: state of gas in aluminum; effect on properties of the metal; origin of the gas in the metal; methods for control of gas content; and methods for counteracting harmful effects of gas present. 131 ref.—BLR.

6.4, 5.9

(Study of the) Anodic Oxidation of Aluminum by Means of Electrochemical, Gas-Volumetric, and Gravimetric Measurements. Leo Cavallaro and Giam Paolo Bolognesi. *Rev. Met.,* **46,** No. 10, 689-694 (1949).

C. and B. studied the anodic oxidation of 99.5% aluminum, containing iron 0.27, silicon 0.19, and copper 0.02%, on small specimens, after polishing on emery paper and pickling in caustic soda and nitric acid. The specimens were oxidized in 15 percent sulphuric acid at 13 V. with lead cathodes for various times, washed in running water and fixed in hot water. Electrochemical determinations were made after immersion in N-H_2SO_4 for 1 hr. followed at ¼-hr. intervals by additions of N-HCl until $N = 3.33$. The volume of hydrogen evolved in N and 5N-HCl was measured. The amount of aluminum oxide produced was weighed. The physico-chemical properties of the anodic films are discussed as functions of the time of treatment in the light of these measurements, which suggest the further protection of the metal by means of organic products, such as hexamethylene tetramine, absorbed on the anodic film.—MA.

6.4, 5.9

Metallic Aluminum in Solution in Liquid Ammonia. Arthur W. Davidson, Jacob Kleinberg, William E. Bennett, and Albert D. McElroy. *J. Amer. Chem. Soc.,* **71,** No. 1, 377-378 (1949).

A letter. In the course of an investigation of the anodic oxidation of aluminum in solutions of various salts in liquid ammonia, the appearance of a deep blue color in the immediate vicinity of the cathode was observed in every case involving electrolysis with aluminum iodide as electrolyte. The color is at first transitory, disappearing upon diffusion into the body of the solution—with the concurrent formation of a white precipitate—and being regenerated at the cathode; on prolonged electrolysis, however, the rate of disappearance gradually decreases, and the entire solution eventually becomes dark blue. The blue solute is considered to consist of ionized metallic aluminum, and a tentative explanation of the phenomena is presented. —MA.

6.4, 8.3, 8.8

Aluminum in the Food and Chemical Industry. Andras Domony. *Aluminum* (Budapest), **1,** No. 1, 6-15 (1949).

The advantages of aluminum and its alloys are discussed, and data are given on the influence of impurities on the resistance to corrosion. A number of precautions are mentioned which have to be observed in the construction of containers for food-stuffs and apparatus for the chemical industry.—MA.

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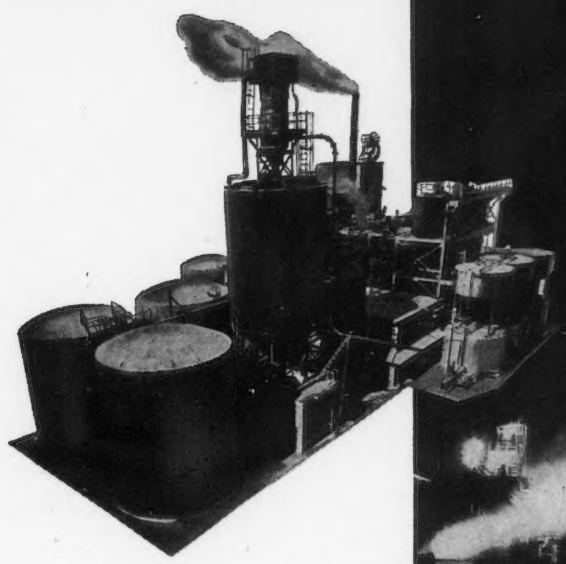

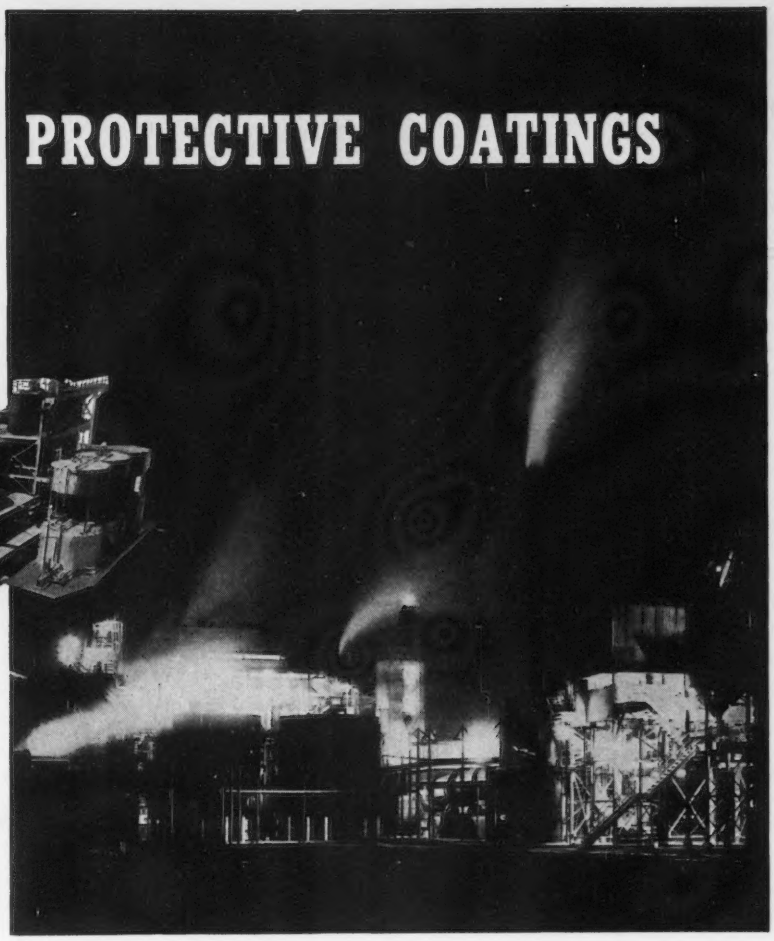

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6.4, 8.4, 8.8

New Uses for Aluminum (in the Petroleum Industry). B. J. Fletcher. *Petro. Proc.*, **4**, No. 10, 1105-1108 (1949).

The applications of aluminum and its alloys in the petroleum industry are reviewed. Among the uses described are: roof and top shell rings of "sour" crude-oil storage tanks, bubble caps, trays, and condensers in refining equipment, pipelines, for the cathodic protection of steel work, for heat-exchanger tubes, electrical conductors, thermal insulation covering, and as aluminum paint.—MA.

6.4, 4.3

The Aluminum Roof in Tropical Service. *Light Metals* (England), **12**, No. 141, 583-585 (1949) Oct.

Results of the examination of light-alloy roofing sheet in actual use under variously unfavorable conditions in a tropical environment are reported. The suitability of aluminum for the purpose is confirmed and its superiority over galvanized sheet and asbestos-cement board is demonstrated.—ALL.

6.4, 4.6, 5.4

Aluminum Alloys and Their Behavior in Spray and Sea Water. Quelques cas de protection et d'assemblage des alliages d'aluminium et leur tenue aux embruns et a la mer. *Metaux et Corrosion* (France), **24**, No. 290, 239-245 (1949) Oct.

In using aluminum alloys for marine purposes, the Navy and Navy Air Arm drew attention to various practical problems. As a result, the following points were investigated: 1) A comparison of the behavior of Al-Cu-Mg alloys in various applications, 2) The efficiency of anodic protection of Al-Mg alloys, 3) The effect of the direct application of anti-fouling paint on Al-Mg and Al-Cu-Mg alloys, plated or bare, and 4) dissimilar assemblies of aluminum to steel and their protection. Following these investigations, salt fog and sea water corrosion tests were made. The following conclusions are drawn: Corrosion was pronounced with Al-Cu-Mg alloys; the plating had a low density and was covered with numerous perforations. With the same thickness of film being applied, the anodic protection of the alloy A-G5 given by treatment in a sodium bisulphate bath proved as good as, if not better than, the customary treatment in sulfuric acid. The direct application of toxic anti-fouling paint containing copper and mercury salts had a particularly bad effect on the alloy A-G5, but no noticeable effect on the alloy A-U4G, bare or plated with A5. The tests on dissimilar assemblies proved that satisfaction depended, for a great part, on the corrosion resistance of the light metal employed, of which the Al-Mg type proved superior. On the other hand, with these assemblies it was found that anodic oxidation was not enough for protection, and that the application of an artificial coating to zones of contact in particular was necessary. This proved especially necessary for bolted joints.—ALL.

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6.4, 3.6, 7.10

Electrolytic Corrosion Eliminated by Nelson Rivweld System. *Modern Metals* (U.S.A.), **5**, No. 12, 22 (1950), Jan.

The Nelson Stud Welding Division of Morton Gregory Corp., Lorain, Ohio, has developed a new fastener which prevents electrolytic corrosion reaction between corrugated aluminum and steel framework by preventing contact at their fastening point. The fastener is called the Nelson composite Rivweld rivet stud, and consists of a flux-filled, cadmium plated steel female stud with a cross-shaped aluminum insert accurately fitted into the stud. The studs are end-welded to the steel by the use of the Nelson pistol-grip welding gun, then the corrugated aluminum is properly positioned and impaled on the studs by a sharp blow with the rubber end of a combination hammer. An aluminum burr is placed over the head of the rivet extension, and hammered to secure the washer in place and provide a tight weather-proof fastening. No electrolytic corrosion is possible at the point of fastening because the aluminum sheet comes in contact only with the aluminum insert and the aluminum burr. The Rivweld system is applicable in construction work, and in metal working industries for end-welding pins, hooks, threaded studs, and special purpose fasteners.—ALL.

6.4, 1.8, 5.9

The Mechanism of Electrolytic Oxidation and the Formation of Oxide Films of Alumina. Le mechanisme de l'oxydation electrolytique et la formation des couches d'oxyde d'alumine. J. Patrie. *Revue de l'Aluminum* (France), **26**, No. 161, 397-403 (1949) Dec.

Anodizing confers higher wear characteristics on light alloy parts for numerous practical uses such as protection against corrosion, decoration, etc. By electrolysis it is possible to obtain alumina layers showing versatile characteristics suitable for a projected practical use, provided the anodic treatment is conducted along rational lines. The study of the influence of the different oxidation factors on the properties of the coatings has led to a theory on the process of formation and development of the oxide film. This theory agrees with the results obtained experimentally and indicates how to modify the conditions of electrolysis to achieve the required results. Several new studies regarding either the measure of the properties of the coating or the obtention of films offering particular properties, show a growing extension of the field of application of anidized light alloy parts; clear and porous films suitable for decoration by dyeing thick and continuous corrosion-resistant films, hard films resistant to abrasion, and flexible films for the electrical insulation of wires and trips. This first section of the article describes the formation of the oxide film, the experimental method for studying oxidation, and different cases of oxidation, such as: 1) the formation of a very compact and strongly insulating oxide layer during oxidation and 2) the formation of a more or less porous layer with a greater thickness. The influence of different factors of oxidation on the porosity of the oxide layer is described.—ALL.

6.4, 1.8

The Electrochemical Behavior of Aluminum. I. The Solutions of Cerium Sulfate in Sulfuric Acid. J. V. Petrocelli. *J. of the Electrochem. Soc.*, **97**, 10-19 (1950) Jan.

Electrode potentials, weight-loss data, and polarization curves are presented, and it is shown that the reaction may be interpreted from an electrochemical point of view. The theory of "mixed potential" is suggested as a more generalized concept than the local cell idea for interpretation of the dissolution process. Outlines probable mechanism for the dissolution and for the passive behavior of Al. 18 ref.—BLR.

• Non-Metallic

6.6

Face Checking of Plywood. H. G. Higgins. Forest Products News Letter, **1948**, No. 160, 2; *Prev. Det. Abs.*, **5**, W 31 (1948).

Checking of plywood is greatest for surface veneers 1/16-inch thick. It can be reduced or even obviated by plastic overlays or suitable paint treatments, but at an increased cost.—RPI.

6.6, 5.9

Wood Preservatives and Their Application. *Ind. Fin.* (Brit.), **1949**, 633-8.

Three classes of preservations are recognized, oil, water-soluble and solvent types. Materials belonging to these classes are briefly discussed. Application methods and the degree of absorption obtained are reviewed.—RPI.

6.6, 3.3, 4.5

Tests to Determine Fungus Resistance of Vinyl Upholstery Treated with Copper 8-Quinolinolate. V. N. Kalberg & C. C. Yeager. Sci. Oil Compounding Co., Report No. SOCCI-CF-101, 1948, 1 p.; *Prev. Det. Abs.*, **6**, C-804 (1949).

A vinyl upholstery material treated with a dispersion in methyl ethyl ketone of 10% copper 8 quinolinoate (copper 8-hydroxy-

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quinoline) in the fabric and 1% copper 8-quinolinolate in the vinyl coating, was buried in soil for 14 days. The treatment was found to give excellent protection against cellulolytic organisms in the soil. —RPI.

6.6, 5.10

Preservative Treatment of Aspen. F. H. Kaufert. U. S. Forest Service, Lake States Aspen Report, 1948, No. 19; *Prev. Det. Abs.*, **6**, W 41 (1949).

Preservative treatments of aspen with coal-tar creosote, dilute solution of pentachlorphenol or copper naphthenate and water-soluble toxics such as $ZnCl_2$, are discussed.—RPI.

EQUIPMENT

• Engines and Turbines

7.1, 3.7, 3.5

Lubrication of the Low Speed Diesel. K. L. Hollister, Texas Co. *Diesel Prog.*, **14**, No. 6, 22-26 (1948) June.

In discussion of lubrication of low-speed Diesel engines, the prevention of corrosion is mentioned. Tables are given showing the effect of temperature and clay dosage on removal of corrosive oxidation products by reclaiming, and the effect of lead in bearing metal on resistance to corrosion.—INCO.

7.1, 8.7

United States Maritime Commission VC2-S-AP2 Cargo Vessels. General Information and Instructions for Operating Engineering Systems. G. S. Sharp. *Marine Eng., & Shipping Rev.*, **53**, No. 6, 60-63; No. 7, 66-9 (1948) June, 1.

Discussion of the principles of operation of lubricating oil system. Pure, moisture-free oil film prevents corrosion of main turbine and gear unit during idle periods. Lubricating oil should be acid-free.—INCO.

7.1

Field Experience With High Sulfur Diesel Fuels. R. J. Furstoss. *SAE Quarterly Trans.*, **3**, 609-615, 638 (1949) Oct.

Inspection of many small-bore, medium-speed, 4-cycle Diesel engines operating throughout the country on fuels having a sulfur content in excess of 0.5% showed that these engines are subject to abnormal ring and cylinder wear and to abnormal combustion-chamber deposits. Engine-design factors most effective in reducing this wear were found to be close control of minimum surface temperature of the liner at the top of the ring travel and use of corrosion-resistant materials. Use of new improved lubricant types minimized deposits and reduced wear.—BLR.

7.1, 3.5

The Formation of Grooves in Anti-Friction Bearings Due to Electrical Corrosion. (In German.) Artur Kohaut. *Zeitschrift fur angewandte Physik*, **1**, 197-211 (1948) Nov.

Experiments were made to determine whether grooves in bearings are the result of electrolysis and whether both ac and dc current produce electrolytic corrosion; also to substantiate the claim that needle bearings are not affected by this type of corrosion. Further experiments showed that flow of materials is the primary cause of groove formation. Includes diagrams, photographs, tables, and graphs. 17 ref.—BLR.

• Valves and Pipes

7.2, 6.3

Construction Materials for Tank Car Valves. *Chem. Eng.*, **56**, No. 10, 204 (1949) Oct.

Material specification on safety, angle, check and sampling line valves used on pressure tank cars are listed by commodity under stainless steel, Monel, and nickel. Monel is to be used for anhydrous HF and liquid Cl_2. Nickel or Hastelloy C is to be used for liquid Br_2.—INCO.

7.2, 6.4

Aluminum Tube Fitting Stops Galvanic Action. *Product Eng.*, **21**, No. 2, 176 (1950) Feb.

The Scovill Manufacturing Company is manufacturing a fitting for use with annealed aluminum tubing which does not cause the galvanic action that is common with brass fittings used with aluminum — consequently, there is no corrosion and weakening of the seal. The fitting is self-contained, two-piece, and has a self-flaring feature. In addition to this self-flaring feature and the leak-proof seal, there is no danger of the tube cracking during flaring, and there is the opportunity to use standard wall tubing rather than the much heavier tubing often required to provide extra strength. These fittings are available in all standard shapes on a made-to-order basis for use with aluminum tubing 3/16 through ½-inch outside diameter.—ALL.

• Containers

7.5, 6.4

Greater Strength Claimed for Aluminum Roof (Of Oil Storage Tank). *Pet. Ref.*, **28**, No. 7, 149 (1949).

A brief description of a self-supporting aluminum roof designed primarily as a roof for oil or chemical storage tanks.—MA.

• Structural Shapes

7.6, 3.5, 1.6, 1.7

American Society for Testing Materials. Panel Discussion on Influence of Non-Ferrous Metals and Their Compounds on Corrosion of Pressure Vessels. Presented at the Fifty-First Annual Meeting, ASTM, Detroit, Michigan, June 24, 1948. Med. 8vo. pp. (v)+ 45, with 13 illustrations. 1948. The Society, 1916 Race St., Philadelphia 3, Pa. Reprinted from *Proc. ASTM*, **48**, 1948(.

Contents: R. B. Donworth, "Station Design and Material Composition as Factors in Boiler Corrosion"; Richard C. Corey, "Corrosion of High-Pressure Steam Generators: Status of Our Knowledge of the Effect of Copper and Oxide Deposits in Steam Generating Tubes," with discussions and combined bibliography.—MA.

7.6, 8.9

A Modern Marine Power Plant. A. W. Woods, U. S. Maritime Comm. Paper before Soc. of Naval Architects & Marine Eng., Phila. Section, Dec. 19, 1947. *Marine Eng. & Shipping Rev.*, **53**, No. 4, 61-66 (1948) Apr.

Salient features of new cargo vessel power plant design and reasons leading to selection of specified equipment. In boilers, use of deaerating feedwater heaters eliminates likelihood of oxygen corrosion. In feed pump, troubles of erosion-corrosion nature found in cycles both low and high-pressure, has been delineated through use of chromium-nickel alloy casings.—INCO.

7.6

Steel Dam in Good Shape After 50 Years. G. W. Lamb, Am. Inst. of Steel Construction. *Eng. News-Record*, **144**, No. 2, 36-37 (1950) Jan. 12.

Steel dam built at Ash Fork in 1898 shows little sign of deterioration—much less than the masonry abutments. In 1898, it was reported that all metal except plates and the structural parts embedded in concrete were given a shop coat of raw linseed oil; also that the plates were cleaned after they were installed and then given a coat of graphite paint. In 1916, it was reported that except for a few scattered pittings there was no evidence of corrosion except in the bottom plates which are in contact with the mud of the reservoir. Right now there is no serious corrosion. Such pitting as was found on face of the dam was of no significance. The pits were painted over and appear old. They were too widely spaced to appear to be ordinary corrosion and might have been caused by ice action on the face before dirt and debris were deposited against it.—INCO.

• Miscellaneous

7.10

Monel Pressure Snubbers Are Corrosion Resistant. *Prod. Eng.*, **21**, No. 3, 190 (1950) Mar.

Monel pressure snubbers have a greater corrosion resistance to certain types of liquids or gases than stainless steel or brass, and are indicated for use with all Monel pressure instruments. They remove one of the chief causes of instrument failure. Mfd. by Chemiquip Sales Co.—INCO.

INDUSTRIES

• Group II

8.2, 5.4

Recent Observations on Anti-Corrosive and Protective Finishes for the Electrical Industry. A. R. Dunton and H. R. Hampson. *J. Oil Colour Chem. Assoc.*, **32**, No. 353, 571-2 (1949) Nov.

A summary of a paper delivered before the Manchester section of the Association. The lecturers discussed ways of observing moisture penetration and the results obtained in recent accelerated weathering tests for priming coats on exposed steelwork. They had investigated the relation between the protection afforded and the viscosity and thickness of the paint films. The efficacy of several proprietary paints and bitumen preparations in protecting the inside of steel water-reservoirs for condenser systems varied greatly, but zinc chromate had shown remarkable performances for periods exceeding two years.—ZDA.

8.2, 3.5

Erosion of Electrical Contacts on Make. L. H. Germer and F. E. Haworth. Appendix A. Effect of Steady Value Current Upon Erosion. D. P.

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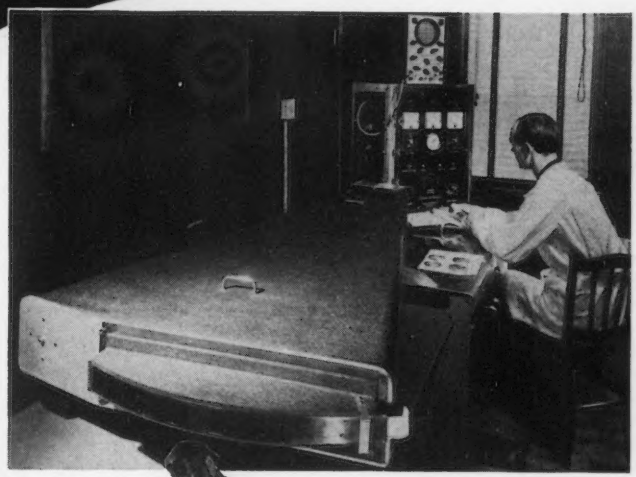

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Ling. *J. of Applied Physics*, **20**, 1085-1109 (1949) Nov.

Concerned here not only with empirical measurement of the erosion, but also with the nature of the discharge which produces it and how both are related to circuit parameters, ambient gas, and other variables. Conclusions are based upon: measurements of the metal transferred from one electrode to the other; microscopic observation of electrode surfaces after a single discharge; determination of the separation at which the discharge occurs; and oscilloscopic records of the discharge. Includes numerous graphs, tables, Fastax camera records, oscilloscope traces, and photo micrographs.—BLR.

8.2, 7.6

40,000-KW Extension to Neches Power Station of Gulf States Utilities Co. A. Kirkpatrick, Stone & Webster Eng. Corp. *Combustion*, **21**, No. 8, 40-46 (1950) Feb.

To avoid corrosion in the airpreheater some hot air is extracted from the forced-draft duct, through a hand-regulated, power-actuated damper and recirculated back to the fan inlet and the air preheater. A further precaution against corrosion was to make the lower plates of the air preheater of low-C, low-Cr or Ni-alloy steel. Feedwater is treated with caustic soda to maintain the desired alkalinity, and Hagan phosphate and sodium sulfate are used as corrosion and embrittlement inhibitors. With a boiler water pH of approximately 10.8 a feedwater pH of 8-8.5 is aimed at by the continuous introduction of sufficient boiler water to maintain this value. The recirculated boiler water is introduced into the shell of the evaporator-condenser; and after cascading with the evaporated makeup into the shells of the two lower extraction heaters, it is pumped into the condensate line to the deaerating heater, thence to the boiler. This procedure is aimed at protecting the piping and the economizer from corrosion.—INCO.

• Group III

8.3

Report of Investigations Into Corrosion Phenomena. Juan J. N. Bonnier. *Rev. Fac. Quim. Ind. Agr.*, **17**, 145-167 (1948); *C. Abs.*, **44**, 101 (1950).

A report of investigations into the causes of corrosion in the San Lorenzo distillery (Argentina), and steps taken to correct conditions. The results are included of an analysis of the water of the Paraná River at San Lorenzo.—MA.

8.3

Two Brewing Plants. M. W. Brenner, Schwarz Labs., Inc. *Ind. Eng. Chem.*, **41**, No. 12, 2939-2945 (1949) Dec.

In 2 gal. brewery, basic unit is a standard 9 qt. stainless steel bain-marie. Lauter tubs have removable false bottoms, either stainless wire cloth in holding rings or conventional slotted bronze. Hops are separated in a few minutes with a stainless steel collander. Each section in a closed cooler for wort cooling is a coil of 0.25-inch stainless tubing. Firestone 2 gal. stainless steel sirup tanks serve as closed fermenters. A nickel alloy and glass pipe-line sirup strainer functions admirably as a diatomaceous earth filter. An Eastern stainless steel centrifugal pump handles liquid transfers. Carbonated beer is filled into bottles with a stainless steel choke coil. In 5 barrel brewery, the brew kettle is completely fabricated from Type 304 stainless steel. Hot wort tank is of Monel. Wort may be cooled through a closed stainless Paraflow plate cooler. Fermenting cellar has 9 tanks, 2 of which are nickel alloy clad steel. In storage and finishing cellar, there is a stainless steel diatomaceous earth filter.—INCO.

8.3, 6.3

The Role of Nickel in Metals for Farm Machinery—IV-V. H. L. Geiger. *Implement & Tractor*, **64**, No. **20**, 26-27, +; No. 21, 44-46 (1949) Oct. 1, Oct. 15.

Discussion of uses of nickel in obtaining strength and top performance in the farm equipment field. Alloy steel parts, many of them nickel steels, are used in small hand garden-type or walking type tractor. Ductile cast iron cast to a chill face appears to offer possibilities for plow points. Ni-Hard is recommended for separation spools. Tables show alloy steel parts for hand garden tractors, relative corrosion rates of plain carbon steel and stainless steel exposed to chemical fertilizers, nickel steel mower parts, and nickel steels and irons for sprayer equipment.—INCO.

8.3, 6.4

Advantages of Aluminum for Milk Transportation. Emile Kohn-Abrest. *Ann. Falsif.*, **42**, 161-165 (1949). *C. Abs.*, **44**, 240 (1950).

The likelihood that aluminum will be corroded in use depends very little on its impurities, but it requires absolute cleanliness and is not suited to liquids containing salt. It is not altered by milk, but is quickly corroded by rum.—MA.

8.3

Metal Clouding in Wine. S. N. Nasledov. *Wine Rev.*, **17**, No. 10, 10-11 (1949) Oct.

Chief cause of metal clouding in wines is due to excell Cu and only to a limited extent to an excess amount of Fe. Excess Cu is picked up by contact with processing equipment. Brass, Cu and Al present in one set-up of operation will accelerate Cu pickup by the wine; the same is true of stainless steel, Cu and Cu alloy combinations. Fe and brass or Cu tends to increase the pickup of Fe by the wine.—INCO.

• Group IV

8.4, 4.6, 7.3

Equipment Selection for Water-Flood Pumping. J. H. Field and E. N. Kemler. Paper before ASME, Petroleum Mech. Eng., Conf., Oklahoma City. *Oil & Gas J.*, **48**, No. 30, 60-61+ (1949) Dec. 1.

Discussion includes pumping requirements, selecting the pumping unit, selection of sucker rods, subsurface pump selection, electrical equipment selection and several rate schedules. If H_2S is the main corroding agent, a nickel-molybdenum (4621) sucker rod may be required. To retard pump corrosion, different metals were tried, including stainless and nickel steels and Monel. Nickel steels appear to be satisfactory where O_2 is the chief corroding agent.—INCO.

8.4

Corrosion. M. A. Furth (Pure Oil Co.). *Oil & Gas J.*, **47**, No. 3, 123 (1948) May 20.

Discussion of the use of alloys to combat and minimize corrosion when neutralization or removal of corrosive agents from materials in refinery operations is not possible. In high temperature sulfur corrosion, 4-6 chromium steel is used. Where H_2S or HCl is present caustic injection is better to neutralize these acidic components especially where acid water is located. Care must be taken to avoid caustic attack on non-ferrous materials in the units.—INCO.

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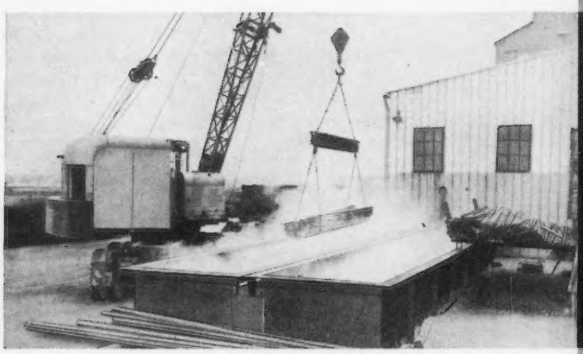

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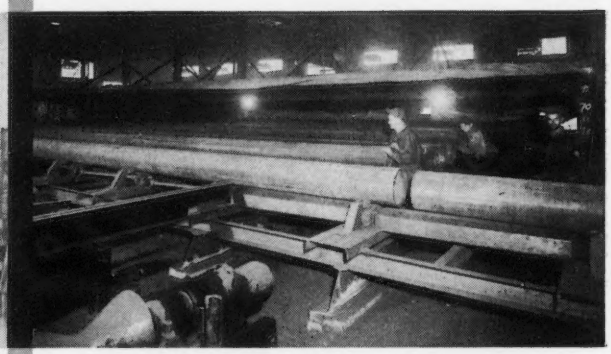

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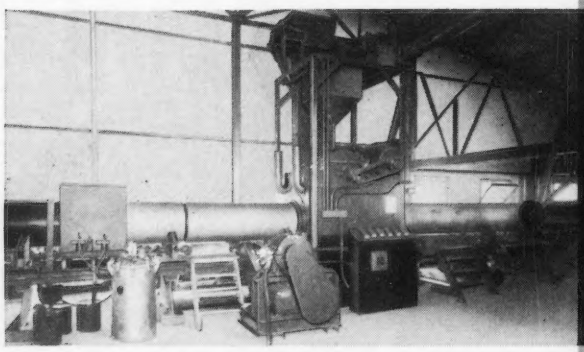

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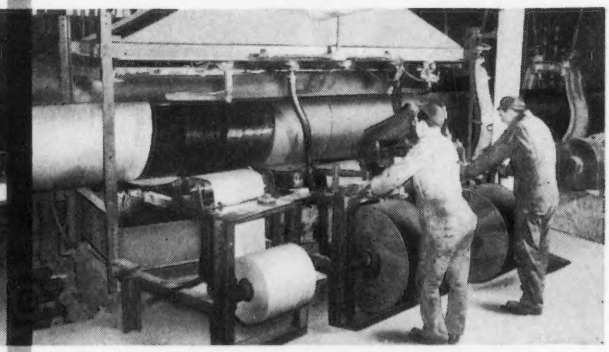

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Bakke, O. M., Houston, Tex.
Baldridge, Willis M., Alton, Ill.
Baldwin, L. A., New York, N. Y.
Ball, Charles I., Cleveland, Ohio
Ball, Norman D., Shreveport, La.
Bammel, Emmett O., Jr., Houston, Tex.
Banfield, George H., Cleveland, Ohio
Bannen, John, South Charleston, W. Va.
Baque, George E., Lima, Ohio
Barb, Melvin V., Denver, Colo.
Barbe, Louie J., Jr., Houston, Tex.
Barcus, E. Dale, Los Angeles, Calif.
Bardsley, Bo, Tulsa, Okla.
Barkow, Carl W., Rifle, Colo.
Barnard, Kenneth N., Dartmouth, Nova Scotia, Canada
Barnard, W. E., Los Angeles, Calif.
Barnes, Frank H., Cranford, N. J.
Barnes, R. Y., Bridgeport, Conn.
Barnett, J. H., Jr., Indianapolis, Ind.
Barnette, B. C., Jr., Sulphur, La.
Barnhill, I. Harry, San Francisco, Calif.
Barr, Clifford L., New Orleans, La.
Barrett, E. D., Detroit, Mich.
Barrett, Jack P., Tulsa, Okla.
Barron, Donald W., New York, N. Y.
Barrow, D. N., Houston, Tex.
Barry, Frederic M., Waterbury, Conn.
Bart, S. G., Belleville, N. J.
Bartmess, Lewis C., Florence, Ala.
Bartolero, Carlo, Oakland, Calif.
Bartolina, Edward A., Tulsa, Okla.
Barton, Clifford R., South Charleston, W. V.
Bartram, Robert William, Montreal, Canada
Basil, John Leslie, Annapolis, Md.
Baskett, Forest, Houston, Tex.
Bassani, F. F., Rock Springs, Wyo.
Bast, Ervin C., Topeka, Kan.
Battle, Jack L., Houston, Tex.
Battle, Thomas J., Jersey City, N. J.
Baughman, George W., Wichita, Kan.
Baublitz, Orville L., Washington, D. C.
Bauer, Jean, Baltimore, Md.
Baumstark, Walter A., St. Louis, Mo.
Baunach, Robert P., Jr., Portland, Ore.
Baxter, Charles V., Salt Lake City, Utah
Beacham, Edward A., Jr., Schenectady, N. Y.
Beam, Russell C., Middletown, Ohio
Beatrix, Raymond H., Paris, France
Beattie, George, Des Moines, Iowa
Bebbington, Marguerite, New York, N. Y.
Beck, Franklin H., Columbus, Ohio
Beck, Walter, New York, N. Y.
Becker, Henry K., Denver, Colo.
Becker, Wm. D., New York, N. Y.
Beckwith, Laurence J., Milwaukee, Wis.
Bedell, H. L., Augusta, Kan.
Bedell, William S., Nederland, Tex.
Beenfeldt, Earl L., Los Angeles, Calif.
Beesley, Glyn W., Dallas, Tex.
Beezley, H. V., Shreveport, La.
Beggs, Charles W., Newark, N. J.
Begole, Edgar Ray, Augusta, Kan.
Behrman, William F., Bayonne, N. J.
Bell, Lawrence H., Coolidge, Ariz.
Bell, Leo A., Odessa, Tex.
Bell, S. J., Houston, Tex.
Bell, W. Rex, Jr., Terre Haute, Ind.
Beller, Clarence J., Cleveland, Ohio
Belson, Maurice W., Shreveport, La.
Bender, Richard B., Mt. Sterling, Ky.
Bennett, Charles E., Paterson, N. J.
Bennett, H. Howard, Paulsboro, N. J.
Bennett, H. R., Shreveport, La.
Bennung, Karl, Jr., Wilmington, Del.
Benson, C. A., Minneapolis, Minn.
Benson, G., Shawinigan Falls, P. Q., Canada
Bent, Edgar D., Montreal, Quebec, Canada
Berg, O. E., Bethlehem, Pa.
Berg, Sigvald L., Hobart, Ind.
Berger, Henry G., Metuchen, N. J.
Bermann, Morton, Brooklyn, N. Y.
Berringer, John C., Kansas City, Mo.
Berry, James H., Jr., Morgan City, La.
Berry, Norton E., Evansville, Ind.
Bertetti, J. W., El Dorado, Ark.
Besse, C. Paul, New Orleans, La.
Best, George E., Baltimore, Md.
Bethon, Henry Edwin, Washington, D. C.
Bialecki, Adolph, Baltimore, Md.
Bialosky, Jerome M., Pittsburgh, Pa.
Biddison, P. McDonald, Tulsa, Okla.
Bielenberg, Arthur C., Davenport, Iowa
Bienvenu, Alan L., Maplewood, La.
Bigger, R. H., Owensboro, Ky.
Bilhartz, H. L., Dallas, Tex.
Binder, William J., Pittsburgh, Pa.
Binder, William O., Niagara Falls, N. Y.
Binger, Wayne W., New Kensington, Pa.
Biondolillo, Sando, Buffalo, N. Y.
Bird, Frank S., New Orleans, La.
Bird, J. D., Boston, Mass.
Bissell, Carl H., Syracuse, N. Y.
Bixby, Willard F., Cleveland, Ohio
Bjorksten, Johan, Madison, Wis.
Black, Bobby E., Los Angeles, Calif.
Black, John S., Jr., Philadelphia, Pa.
Black, Ralph P., Jr., Kansas City, Mo.
Blackburn, Douglas B., Brooklyn, N. Y.
Blackburn, Duncan A., Pasadena, Calif.
Blackman, Bruce A., Tulsa, Okla.
Blaese, Arnold C., Battle Creek, Mich.
Blaine, Russell K., Peoria, Ill.
Blair, Charles M., Webster Groves, Mo.
Blair, John V., Tulsa, Okla.
Blake, George H., Newark, N. J.
Blake, J. A., Los Angeles, Calif.
Blanchard, C. A., Houston, Tex.
Blanco, Felix F., Bernal, Prov. de Buenos Aires, Rep. Argentina
Blanda, Peter, Crane, Tex.
Blankenship, Fred R., Jr., Birmingham, Ala.
Blecksmith, C. C., Los Angeles, Calif.
Bliler, Roy K., Fort Worth, Tex.
Blish, Ervin R., Meade, Kan.
Bloch, Peter K., Stamford, Conn.
Bloch, Roger, Paris, France
Blohm, Clyde L., Los Angeles, Calif.
Blundell, Edwin L., Joliet, Ill.
Boberg, Irving E., Chicago, Ill.
Bock, Morris, Dallas, Tex.
Bodfish, Howes, Baltimore, Md.
Bohne, A. W., Evanston, Ill.
Bolling, John G., Evanston, Ill.
Boltz, David C., Long Island, N. Y.
Bond, Donald H., Houston, Tex.
Bonnet, Robert W., Lafayette, Ind.
Bonstow, Thomas L., London, S. W. 1, UK, England
Book, C. C., Pauls Valley, Okla.
Boone, Harold C., Joliet, Ill.
Booth, Robert C., Houston, Tex.
Borst, George E., Philadelphia, Pa.
Bosley, Samuel E., Tulsa, Okla.
Bossard, Leroy T., Tulsa, Okla.
Bossert, Earl D., Philadelphia, Pa.
Bost, Armon H., Tulsa, Okla.
Bost, Paul L., St. Louis, Mo.
Bourgeois, Earle, Norco, La.
Bowan, Walter J., Decatur, Ill.
Bowden, Raymond C., Jr., Pittsburgh, Pa.
Bowen, James V., Los Angeles, Calif.
Bowen, Lloyd O., Jr., Shreveport, La.
Bowen, Milton M., Cleveland, Ohio
Bowman, John V., Houston, Tex.
Boyce, Trevor G., Houston, Tex.
Boyd, George E., New York, N. Y.
Boyd, P. B., Atlanta, Ga.
Boyd, William G., Jr., Houston, Tex.
Boylan, James A., Detroit, Mich.
Bradbury, J. E., Chicago, Ill.
Bradfield, Stephen A., Los Angeles, Calif.
Bradley, Bryant W., Houston, Tex.
Bradley, F. E., Los Angeles, Calif.
Brady, Hugh A., Tulsa, Okla.
Brady, James M., Wilmington, Del.
Brady, Merritt H., Emeryville, Calif.
Brady, Thomas E., Cranford, N. J.
Bralley, J. C., Cushing, Okla.
Bramble, Lloyd F., South Houston, Tex.
Bramlette, Robert C., Birmingham, Ala.
Brannon, R. A., Houston, Tex.
Branson, Edward H., Rochester, N. Y.
Branton, James A., Norman, Okla.
Brasunas, Anton Desales, Oak Ridge, Tenn.
Braun, F. C., Pittsburgh, Pa.
Brauning, J. F., Chicago, Ill.
Brecheisen, Charles M., Wichita, Kan.
Breeze, Lewis K., Cleveland, Ohio
Breitenbach, Paul, El Cerrito, Calif.
Bremer, Clarence, New York, N. Y.
Brendel, Robert O., Houston, Tex.
Brennan, John R., Los Nietos, Calif.
Breshears, Frank S., Jr., Houston, Tex.
Breslin, Jack D., Houston, Tex.
Brewer, John E., Wood River, Ill.
Brich, John G., Lyndora, Pa.
Bried, Edward A., Wilmington, Del.
Briggs, Gerald F., St. Paul, Minn.
Briggs, H. L., Los Angeles, Calif.
Briggs, W. R., Philadelphia, Pa.
Brightly, Frederick C., Jr., Oak Park, Ill.
Brinen, Howard F., Racine, Wis.
Brink, Edward G., Media, Pa.
Britton, H. B., New York, N. Y.
Brock, Chelsey L., Jr., Houston, Tex.
Bronstein, Emanuel H., Barberton, Ohio
Brookes, A. Sidney, Newark, N. J.
Brooks, Jerrell Eugene, Ashland, Ky.
Brooks, Richard H., Jr., Tulsa, Okla.
Brooks, William B., Freeport, Tex.
Broom, Charles M., Miami, Fla.
Broome, W. A., Shreveport, La.
Brough, Harry R., Salt Lake City, Utah
Broussard, Edward A., Houston, Tex.
Brown, Charles D., Houston, Tex.
Brown, Charles J., New York, N. Y.
Brown, Donald C., Odessa, Tex.
Brown, George F., Port Arthur, Tex.
Brown, Gordon W., Brooklyn, N. Y.
Brown, H. D., Tulsa, Okla.
Brown, Harold H., Appleton, Wis.
Brown, Harry F., New Haven, Conn.
Brown, John R., Inglewood, Calif.
Brown, Kenneth W., San Francisco, Calif.
Brown, Marshall H., Wilmington, Del.
Brown, R. H., New Kensington, Pa.
Brown, Ual J., Oklahoma City, Okla.
Brown, Vernon M., Lake Charles, La.
Browne, John J., Wilmington, Calif.
Brownie, F. A., Calgary, Alberta, Canada
Browning, R. T., Belleville, N. J.
Broyles, Wayne E., Houston, Tex.
Brudvig, Lloyd A., Houston, Tex.
Bruhn, H. W., Omaha, Neb.
Brunkow, Ivan L., Tulsa, Okla.

Bruno, Charles A.....Marcus Hook, Pa.
Bruse, Wm. E.....Elgin, Ill.
Brush, Edwin G....Pittsfield, Mass.
Bruyere, Wm. H.....Houston, Tex.
Bryson, James A...Libertyville, Ill.
Buchan, Rudolph C...Houston, Tex.
Buchanan, William C..Houston, Tex.
Buck, D. C. .....Pittsburgh, Pa.
Buckley, Fred S....Des Plaines, Ill.
Buddrus, E.....Kansas City, Mo.
Buehler, Martin J. H.....Philadelphia, Pa.
Buehlmann, J. G.....Depew, N. Y.
Buell, James H.....Chicago, Ill.
Buell, Norman S.....San Francisco, Calif.
Buensod, A. C.....New York, N. Y.
Buettner, Walter J....Chicago, Ill.
Bullock, Robert L.....Tulsa, Okla.
Bulow, C. L.....Bridgeport, Conn.
Bundrant, Charles Ollie.....Midland, Tex.
Bundy, Alfred D....Cleveland, Ohio
Bunting, William E....Chicago, Ill.
Burd, Harry G.....Ansonia, Conn.
Burgess, Wilbur T.....Omaha, Neb.
Burlingame, M. V.....Chicago, Ill.
Burnett, Graydon E...Denver, Colo.
Burnett, William C.....Charlotte, N. C.
Burns, C. A.....Lake Charles, La.
Burns, D. L.....Port Arthur, Tex.
Busby, A. H. Wilson.....Trail, British Columbia, Canada
Busch, Paul E.....Shreveport, La.
Bush, Cecil D.....North Baton Rouge, La.
Butler, C. A., Jr...Painesville, Ohio
Butler, Edward B.....Falls Church, Va.
Butler, James H.....Corpus Christi, Tex.
Butterbaugh, Homer W.....Kenosha, Wis.
Byarre, Wm. W....Philadelphia, Pa.

C

Cahill, Joe L.....Houston, Tex.
Caldwell, John C..Philadelphia, Pa.
Caldwell, Joseph A....Houston, Tex.
Callahan, Melvin C....Tulsa, Okla.
Callahan, V. L.....Baltimore, Md.
Calvert, R. C. M., Jr.....Hilton Village, Va.
Cameron, L. J...San Antonio, Tex.
Cameron, William B.....Brooklyn, N. Y.
Camp, Eldridge K.....East Pittsburgh, Pa.
Camp, E. Q.....Baytown, Tex.
Campbell, A. B.....Houston, Tex.
Campbell, J. G.....Tulsa, Okla.
Campbell, John G.....Corpus Christi, Tex.
Campbell, Richard C.....Midland, Mich.
Canfield, T. L.....Lawton, Okla.
Cann, Kenneth R.....Phillipsburg, N. J.
Canning, George R.....East Cleveland, Ohio
Cannon, Curtis W....Wichita, Kan.
Cantwell, Guy H., Indianapolis, Ind.
Capaul, R. W.....Waterville, Ohio
Cardwell, Paul H.....Tulsa, Okla.
Carlson, Eric G., Philadelphia, Pa.
Carmichael, Miles .....Oklahoma City, Okla.
Carmouche, H. D....Houston, Tex.
Carpenter, Dan H.....Oklahoma City, Okla.
Carpenter, G. Carey.....Baton Rouge, La.
Carr, Joseph A...Ridgewood, N. J.
Carson, John H....Cleveland, Ohio
Carter, Anthony J....Newark, Ohio
Carter, Geo. M., Jr.....Minneapolis, Minn.
Case, L. C.....Tulsa, Okla.
Case, William W., Springfield, Mass.
Casey, J. Pat, Jr.....Chicago, Ill.
Castle, Harry, Jr..Jacksonville, Tex.
Cates, Walter H.....Los Angeles, Calif.
Cathcart, Wallace P..Pittsburgh, Pa.
Cavanagh, W. R.....Detroit, Mich.
Caveney, Jack E.....Chicago, Ill.
Cayford, James M...Cleveland, Ohio
Ceccon, J. B.....Chauncey, N. Y.
Chadwick, David H...Anniston, Ala.
Chadwick, R. H.....Salt Lake City, Utah
Chalmers, William H.....Rawalpindi, West Punjaub, Pakistan
Chambers, Alexander R., Jr.....Pittsburgh, Pa.
Chandler, John W...Buffalo, N. Y.
Chaney, Leonard P....Houston, Tex.
Chapman, E. E.....Chicago, Ill.
Chapman, Walter H..Phoenix, Ariz.
Chatelain, John B....Freeport, Tex.
Chatenever, Alfred, Norman, Okla.
Cherry, R.....Texas City, Tex.
Chesnutt, N. P.....Dallas, Tex.
Chiasson, Crawford Ellis.....West Lake, La.
Childs, Benjamin F.....Washington, D. C.
Chisholm, Charles G...Kokomo, Ind.
Christ, George J...Brooklyn, N. Y.
Christian, James W.....Texas City, Tex.
Church, Laurence T..Springfield, Ill.
Ciborski, John M....Brooklyn, N. Y.
Cibula, Henry J.....Pittsburgh, Pa.
Claiborne, Tom A...Cleveland, Ohio
Clancy, J. J.....Chicago, Ill.
Clark, Claude L.....Canton, Ohio
Clark, Hezzie.....Houston, Tex.
Clark, Joseph B.....Tulsa, Okla.
Clark, Manley H.....Newport Beach, Calif.
Clark, Peter.....Abadan, Iran
Clarke, B. C....Los Angeles, Calif.
Clarke, Edward Dean..Muncie, Ind.
Clarke, Richard P.....Port Arthur, Tex.
Clarvoe, George W...Manville, N. J.
Clausen, C. C.....Dixon, Ill.
Clay, James A., Jr.....Fort Worth, Tex.
Clayton, Henry M...Memphis, Tenn.
Clayton, William J....Detroit, Mich.
Clifford, Hugh J....Lockport, N. Y.
Clifton, W. M.....Amarillo, Tex.
Cloninger, Fred M.....Tulsa, Okla.
Cloud, C. E.....Tulsa, Okla.
Cloyes, William P.....Boulder City, Nev.
Coates, Proctor G.....Detroit, Mich.
Coats, Sanford C.....Oklahoma City, Okla.
Cobb, Stephen P.....Ashville, N. C.
Cobbett, C. D., New Kensington, Pa.
Coberly, Camden A...St. Louis, Mo.
Coe, Russell H.....Pittsburgh, Pa.
Cofield, William W.....Englewood, N. J.
Coghill, H. T.....Chicago, Ill.
Cogshall, James H.....Wyandotte, Mich.
Cohen, Benjamin J.....Jersey City, N. J.
Cohen, Ralph.....Nutley, N. J.
Colburn, Lyle W.....Midland, Mich.
Cole, Frank H.....New York, N. Y.
Cole, R. J..Toronto, Ontario, Canada
Cole, Ralph R.....Dallas, Tex.
Cole, Robert M.....Ft. Worth, Tex.
Coleman, O. K.....Lafayette, Ind.
Coleman, W. B....Philadelphia, Pa.
Coleman, W. D.....Springfield, Mo.
Coley, Glenn.....Detroit, Mich.
Collins, Harry S.....Long Island City, N. Y.
Collins, J. L.....Angleton, Tex.
Collins, James H., New Orleans, La.
Collins, Walter F., New York, N. Y.
Collora, Nicholas A.....Terre Haute, Ind.
Comeaux, Roy V. ....Baytown, Tex.
Compton, Kenneth G.....Murray Hill, N. J.
Conde, Luis Lopez.....Maracaibo, Venezuela
Condry, James T.....Tulsa, Okla.
Connell, Jasper S.....Wilmington, Calif.
Connelly, D. J.....Cleveland, Ohio
Connon, William D.....Philadelphia, Pa.
Connors, William F...Houston, Tex.
Conrad, Howard P.....Port Huron, Mich.
Conroy, John H.....Houston, Tex.
Converse, E. M.....Chicago, Ill.
Conviser, M. B....Kingsport, Tenn.
Cook, George S.....Scotia, N. Y.
Cook, Lawrence S....Allenport, Pa.
Cook, Leon D., Jr.....Wyandotte, Mich.
Cook, W. B.....Port Arthur, Tex.
Coolbaugh, William E.....Peru, Ill.
Cooley, Herbert M.....Tulsa, Okla.
Coons, Ansel L...San Antonio, Tex.
Cooper, George E.....Miami, Fla.
Cooper, Wm. C.....Cudahy, Wis.
Copley, James S....Cleveland, Ohio
Copson, Harry R...Cranford, N. J.
Cordell, P. M.....Ft. Worth, Tex.
Corfield, Guy....Los Angeles, Calif.
Cornett, W. J....Galena Park, Tex.
Corwin, Gerald A.....Chicago, Ill.
Costanzo, Frank E., Pittsburgh, Pa.
Coursey, Ralph W.....Oklahoma City, Okla.
Court, W. F.....New York, N. Y.
Couy, C. J.....McKeesport, Pa.
Cowart, B. C....New York, N. Y.
Cowles, James R.....Tulsa, Okla.
Cox, A. F.....Amarillo, Tex.
Cox, Edwin S.....Pittsburgh, Pa.
Cox, Gaylord H...Lake Charles, La.
Cox, George C., Charleston, W. Va.
Cox, Gilbert L....Rochester, N. Y.
Cox, John W....Salt Lake City, Utah
Coyle, T. G.....New York, N. Y.
Craig, Fred L.....Houston, Tex.
Craig, James H...New Orleans, La.
Cramer, Anthony H...Detroit, Mich.
Crane, Harold E., Jr.....Pittsburgh, Pa.
Crane, James.....Cincinnati, Ohio
Craver, Albert F....Cleveland, Ohio
Crawford, Guy C...Fort Worth, Tex.
Crawford, W. E...Milwaukee, Wis.
Creevy, Joseph A.....Newport, Ky.
Crenshaw, William H.....Midland, Tex.
Cribley, K. C., Corpus Christi, Tex.
Crobaugh, Albert O..Caldwell, N. J.
Cromeans, Olyndia L.....Maplewood, La.
Croney, Samuel I..Philadelphia, Pa.
Crosby, William L.....New York, N. Y.
Crossman, R. Nathan.Houston, Tex.
Crowe, Raymond H...Houston, Tex.
Culbertson, J. L....Beirut, Lebanon
Cummer, William F...Beeville, Tex.
Cummins, Frank M...St. Louis, Mo.
Curley, William R.....Clarksburg, W. Va.
Curran, James J., Greensburg, Pa.
Curran, Michael .....Tulsa, Okla.
Current, F. Lee.....Oil City, Pa.
Curtis, Robert W....Alliance, Ohio
Cushing, Daniel.....Boston, Mass.
Cushman, George A., Brenham, Tex.
Cutting, Merritt E.....South Barre, Mass.

D

Daino, Pietro.....Naples, Italy
Dale, Dudley R.....Toledo, Ohio
Dalrymple, Robert S.....Richland, Wash.
Daniels, Leonard J., Jr.....Fort Worth, Tex.
Danne, Herbert J.....Tulsa, Okla.
Dantz, Thomas M., New York, N. Y.
Danser, J. W.....New York, N. Y.
DaRin, Edward J.....South Euclid, Ohio
Darling, P. E.....Texas City, Tex.
Darrin, Marc.....Baltimore, Md.
Daugherty, James G.....Philadelphia, Pa.
Davenport, John A..Cincinnati, Ohio
Davie, Frank E.....Tracy, Calif.
Davis, Billy H.....Houston, Tex.
Davis, Carl R.....Butte, Mont.
Davis, Charles T., Jr..Houston, Tex.
Davis, Edwin G...Haddonfield, N. J.
Davis, F. W.....Washington, D. C.
Davis, George W.....San Francisco, Calif.
Davis, J. E.....Fort Worth, Tex.
Davis, Jack G.....Houston, Tex.
Davis, Jas. A.....Fort Worth, Tex.
Davis, Leon B...Washington, D. C.
Davis, Leroy J.....Glencoe, Ill.
Davis, L. W.....Cleveland, Ohio
Davis, Robert A., Birmingham, Ala.
Davis, Russell L.....Awali, Bahrein Island Persian Gulf
Dawson, R. A. J.....Houston, Tex.
Day, Clyde W.....Bishop, Tex.
Day, Kenneth A.....Denver, Colo.
Day, Stephen D.....Houston, Tex.
Deacon, Wm. T.....St. Louis, Mo.
Deacon, William T., III .....St. Louis, Mo.
Deaconson, James N.....Wilmington, Del.
Dean, John E.....Kingsville, Tex.
Dean, Lyle A...Walnut Creek, Calif.
Dean, Roy O.....Emeryville, Calif.
Deavenport, John L....Minden, La.
Debeers, Franklin M., Jr.....Glenview, Ill.
Debevoise, George D.....Brooklyn, N. Y.
DeCowsky, George N.....Philadelphia, Pa.
Debord, George E.....Galena Park, Tex.
Deering, F. A.....Arkansas, Kan.
Deering, Robert G...Beaumont, Tex.
Degenhart, Thurlo E..Vallejo, Calif.
Degnan, Thomas F.....Penns Grove, N. J.
Dehaan, Peter C...Des Moines, Iowa
Deichler, J. K.....Philadelphia Pa.
DeKay, Charles R...Jackson, Miss.
Delahay, Paul....Baton Rouge, La.
De Laski, Robert D.....New York, N. Y.
De Long, William B.....Wilmington, Del.
De Mey, C. F....New York, N. Y.
de Minjer, Clara Henderina Gloeilampenfabrieken, Eindhoven, Holland
Denison, Irving A.....Washington, D. C.
Dennis, Sidney.....St. Louis, Mo.
Denoon, E. M.....Miami, Fla.
Dent, Herbert W., Jr.....Birmingham, Ala.
DePaul, D. J.....Homestead, Pa.
Dequine, Louis E., Jr.....Elizabethton, Tenn.
Deringer, Wayne A.....Milwaukee, Wis.
Detrick, Charles N., Cleveland, Ohio
Deuber, Carl G.....Ardsley, N. Y.
Devoluy, Raymond, New York, N. Y.
Dewar, J. S.....Bartlesville, Okla.
Dewar, William ....Philadelphia, Pa.
Dey, Charles L....Pittsburgh, Pa.
Diamond, Horace W....Chicago, Ill.
Dick, Howard C.....Westwego, La.
Dickinson, L. R...New York, N. Y.
Dickinson, W. F., Los Angeles, Calif.
Dieck, Herbert W....Mineola, N. Y.
Diecks, A. Norman.....Philadelphia, Pa.
Diehlman, George..Brooklyn, N. Y.
Dietsch, F. F....Washington, D. C.
Dietz, Clifton E.....Beeville, Tex.
Dietze, Irwin C..Los Angeles, Calif.
Diggins, Earl R.....New Kensington, Pa.
Dillon, Charles P...Texas City, Tex.
Dirks, Richard W.....Beeville, Tex.
Dix, E. H., Jr..New Kensington, Pa.
Dobbs, Cecil I.....La Gunillas, Eda, Zulia, Venezuela
Dod, A. Bayard, Jr.....Los Angeles, Calif.
Dodgen, James E....Drexel Hill, Pa.
Doelling, George L....St. Louis, Mo.
Dolson, Frank E., Jr.....University City, Mo.
Donati, Enrico .....Dalmine, Bergamo, Italy
Donnelly, Joseph B.....Philadelphia, Pa.
Donnelly, Lt. Patrick R.....Oceanside, Calif
Donoho, Chas. K., Birmingham, Ala.
Donovan, Lewis B., New York, N. Y.
Donovan, W. H., Jr.....Birmingham, Ala.
Doremus, E. P.....Houston, Tex.
Doremus, Gordon L...Houston, Tex.
Dorr, Frank I., Jr....Houston, Tex.
Dorsey, Joseph S.....Los Angeles, Calif.
Doss, Glenn K.....Roselle, N. J.
Dougherty, Wm. J..Sioux City, Iowa
Doughty, S. E.....Union, N. J.
Douglass, Dwight...Hartford, Conn.
Douglass, E. W.....Carlsbad, N. M.
Douglass, Harry E.....Los Angeles, Calif.
Dowling, Roy C.....Appleton, Wis.
Doyle, John M.....Chicago, Ill.
Dragics, Earl V.....Houston, Tex.
Draughon, Charles R.....Baton Rouge, La.
Dravnieks, Andrew.....Chicago, Ill.
Drewelow, Earl.....Joplin, Mo.
Dreyman, Edgar W.....Brooklyn, N. Y.
Dubois, Carlton H....Buffalo, N. Y.
Duce, R. E....Webster Groves, Mo.
Duffner, Gordon H.....Chicago, Ill.
Duggan, James J.....South Charleston, W. Va.
Duggan, Maryann.....Dallas, Tex.
Duim, Albert R..Los Angeles, Calif.
Dunagan, George M.....Salem, Ill.
Dunasky, C. F.....Cleveland, Ohio
Dunham, R. A...Long Beach, Calif.
Dunn, E. F.....Buffalo, N. Y.
Dunning, Sheldon....Seattle, Wash.
Duree, Jack T....Fort Worth, Tex.
Durning, A. W...New Orleans, La.
Dutton, W. L.....Chatham, Ontario, Canada
Dwyer, James T., Jr.....Port Arthur, Tex.
Dwyer, T. J.....Baltimore, Md.
Dyble, Edward.....Cleveland, Ohio

E

Earl, Robert, Jr.....Utica, N. Y.
Earnshaw, Charles S.....Oakland, Calif.
Easson, Wm. H.....Chicago, Ill.
Ebbs, Edward L....Houston, Tex.
Eberhardt, Ernest T.....Hackensack, N. J.
Eberhardt, T. J...Hackensack, N. J.
Ebersole, Larue Kenmore.....Colorado Springs, Colo.
Ebert, Raymond E....St. Louis, Mo.
Eckles, W. W.....Beaumont, Tex.
Eckmann, Clarence W.....Wyandotte, Mich.
Eddison, Clifford.....Camden, N. J.
Eddy, Levi C.....Hinsdale, Ill.
Edmonson, A. Glen.....Jacksonville, Fla.
Edwards, Marvin J.....San Diego, Calif.
Edwards, W. H.....Bellaire, Tex.
Effinger, R. T.....Martinez, Calif.
Egan, T. E.....Grove City, Pa.
Egly, Richard S., Terre Haute, Ind.
Eickoff, Arnold J...Brooklyn, N. Y.
Eilerts, C. Kenneth.....Bartlesville, Okla.
Elder, John W.....Tulsa, Okla.
Elder, Lowell L....Columbus, Ohio
Elkins, Randell L....Midland, Tex.
Ellerbrake, Earl G..Cleveland, Ohio
Eldred, Norman O.....Vicksburg, Mich.
Eldredge, George .....Emeryville, Calif.
Elliott, Jack H..Los Angeles, Calif.
Elliott, Robert D.....Dallas, Tex.
Ellis, O. B.....Middletown, Ohio
Elliston, H. H.....Tulsa, Okla.
Elsener, L. A., San Francisco, Calif.
Emerson, Richard J...El Paso, Tex.
Emery, Maurice N.....Corpus Christi, Tex.
Enders, Roger S..Long Beach, Calif.
Endicott, L. A.....Texas City, Tex.

Engelhardt, Robert Lee.....Glendale, Calif.
Engle, J. Preston....Alliance, Ohio
English, E. Rowland.....Philadelphia, Pa.
English, Gyme C.....New Kensington, Pa.
English, James L..Oak Ridge, Tenn.
Enquist, Melvin A.....Alhambra, Calif.
Eplett, Albert D., Stratford, Conn.
Erganian, Alex M....Houston, Tex.
Erickson, Bert E.....Salt Lake City, Utah
Erickson, C. A., Jr., Pittsburgh, Pa.
Erickson, E. T.....Chicago, Ill.
Ericson, Rudolph C., Hammond, Ind.
Eubanks, Erdie B., Jr.....Los Angeles, Calif.
Evans, C. W.....Shreveport, La.
Evans, Charles T., Jr., Delmont, Pa.
Evans, Clair O....New York, N. Y.
Evans, David H.....Toronto, Ontario, Canada
Evans, Dwight J.....Tulsa, Okla.
Evans, Herbert V., Jr.....Pittsburgh, Pa.
Evans, Herschel....Scottsbluff, Neb.
Evans, J. M...San Francisco, Calif.
Evans, Rulison...Wilkes-Barre, Pa.
Evans, Thomas C.....Orange, Tex.
Everest, Guy N.....Canal, Passaic, N. J.
Everett, Ralph H., New York, N. Y.
Everhart, E. Wayne.....Spokane, Wash.
Eves, W. D. Heath..New York, N. Y.
Ewing, L. W., Jr.....Chicago, Ill.
Ewing, Scott P.....Tulsa, Okla.
Exum, James P., Jr.....Beaumont, Tex.

F

Fair, W. F., Jr.....Westfield, N. J
Fanett, H. M.....Houston, Tex.
Farber, J. D.....Philadelphia, Pa.
Farkas, Howard...New York, N. Y.
Farley, Elden R.....Houston, Tex.
Farmer, C. E.....Shreveport, La.
Farmer, Sidney C., Jr.....Galveston, Tex.
Farrar, Walter B.....Bethesda, Md.
Farwell, Milo S.....San Francisco, Calif.
Fasig, Paul L.....Woodbury, N. J.
Fasold, G. Arthur, Cincinnati, Ohio
Featherly, Robert L.....Saginaw, Mich.
Feldman, Karl T.....Independence, Kan.
Feldstein, Henry H..Cleveland, Ohio
Fell, Paul D....Independence, Kan.
Feller, Eugene W. F.....St. Joseph, Mich.
Fellows, Claire H.....Huntington Woods, Mich.
Fenn, George P.....Peoria, Ill.
Fenner, Otto H.....St. Louis, Mo.
Fergus, D. J.....Cleveland, Ohio
Fergusson, Robert A., Evanston, Ill.
Fernandez, Henry J.....Texas City, Tex.
Ferree, Ray J.....St. Louis, Mo.
Fetner, Charles J., Jr.....Vandergrift, Pa.
Fetters, Karl L...Youngstown, Ohio
Fiedelman, Howard W.....Manistee, Mich.
Filkins, Harry L...Kansas City, Mo.
Fincher, D. R.....Palestine, Tex.
Fink, Frederick W., Columbus, Ohio
Finlay, Daniel F..Melvindale, Mich.
Fischer, H. E.....Houston, Tex.
Fisher, B. M.....Freeport, Tex.
Fisher, Earl E....Philadelphia, Pa.
Fisher, George A., Jr..St. Louis, Mo.
Fithian, John W...Philadelphia, Pa.
Fitzgerald, J. Wilfrid.....Cleveland, Ohio
Fitzpatrick, Allyn H.....Kansas City, Mo.
Flanagan, J. C.....Houston, Tex.
Flanders, Albert C.....Benwood, W. Va.
Fleming, M. C...Bartlesville, Okla.
Fleming, Tom L.....St. Louis, Mo.
Fleming, Thomas J.....Santa Monica, Calif.
Flentje, Martin E..Philadelphia, Pa.
Fletcher, Frederic H....Tulsa, Okla.
Fletcher, Mark D.....Chicago, Ill.
Flickinger, L. C., Youngstown, Ohio
Flint, J. W.....Wichita, Kan.
Flocke, Frank G.....Cleveland, Ohio
Flood, Earl F.....Hudson, Ohio
Flor, Loy L.....La Mesa, Calif.
Flournoy, R. W.....Argo, Ill.
Foelsch, Henry W.....Chicago, Ill.
Fogle, Howell P.....Houston, Tex.
Fontana, M. G.....Columbus, Ohio
Footner, H. B.....Great St. Helen's, London E. C. 3, England
Forbes, A. L., Jr.....Houston, Tex.
Forbes, M. C.....Houston, Tex.
Ford, Charles D....Monrovia, Calif.
Forsha, William D.....Pampa, Tex.
Fort, George A.....Gary, Ind.
Fossett, W. K.....Wichita, Kan.
Foster, Albert C., New York, N. Y.
Foster, J. L.....Dallas, Tex.
Fouraker, Robert W.....Wilmington, Calif.
Fox, Arthur R.....Oakland, Calif.
Fox, R. W.....Newton Square, Pa.
Francis, Howard T.....Chicago, Ill.
Franek, John A....Cincinnati, Ohio
Frank, Marion E.....Houston, Tex.
Frasch, H. H.....Dallas, Tex.
Fraser, John P.....Walnut Creek, Calif.
Fredenburg, Charles W.....Chicago, Ill.
Frederickson, Hubert M.....Minneapolis, Minn.
Fredley, Kenneth C.....Pittsburgh, Pa.
Freeman, C. E.....Berkeley, Calif.
Freeman, John R., Jr.....Waterbury, Conn.
Freeman, Richard S.....Lake Charles, La.
Freynik, Henry S...Riverside, N. J.
Friant, Stewart.....Baltimore, Md.
Frieden, Alexander..Milwaukee, Wis.
Friedl, Burt.....Columbus, Ohio
Friedman, Charles.....Long Island City, N. Y.
Friend, W. Z.....New York, N. Y.
Frink, Joe.....Miami, Fla.
Fritts, Charles J.....Dallas, Tex.
Fritts, Harry W.....New Kensington, Pa.
Friz, Nelson.....New York, N. Y.
Frye, Seymour Charles.....Bethlehem, Pa.
Fryer, Carl V.....Cyril, Okla.
Fugazzi, John F.....Denver, Colo.
Fullman, James B..Stamford, Conn.
Funck, Donald E...Manhatten, Kan.
Funk, F. W.....Akron, Ohio
Furgason, Clyde A....Cudahy, Wis.
Furr, Albert T., Jr.....Baton Rouge, La.
Furth, M. A.....Nederland, Tex.

G

Gackenbach, Russell E.....Bound Brook, N. J.
Gaido, S. J.....Harvey, La.
Gaidry, H. L....New Orleans, La.
Gallagher, John S.....Los Angeles, Calif.
Galloway, Joseph F.....Cleveland, Ohio
Gallup, Dudley D.....Thorndale, Pa.
Gally, Sidney K....Pasadena, Calif.
Gamble, Chas. B., Jr.....Birmingham, Ala.
Gamble, George P....St. Louis, Mo.
Garber, Glenn D., Lake Charles, La.
Garcia, Luis.....Wayne, Mich.
Gard, Charles M.....Worthington, Ohio
Gardner, Franklin T., Tulsa, Okla.
Gardner, G. Douglas, Louisiana, Mo.
Gardner, Gerald C.....Hazelwood, Pittsburgh, Pa.
Gardner, Karl A...New York, N. Y.
Garrett, Fred A.....Dallas, Tex.
Garrett, G. H.....Denver, Colo.
Garrett, William W.....Birmingham, Ala.
Garrison, V. L.....Paterson, N. J.
Geary, Arthur L...Cambridge, Mass.
Gee, Edwin A.....Newport, Del.
Gegner, Paul J.....Barberton, Ohio
Gehlen, Carl.....Pelham, N. Y.
Gensberg, Aaron.....Odessa, Tex.
Gerben, Max.....Long Island, N. Y.
Gerlovich, C. Lewis...Houston, Tex.
German, Alfred...New York, N. Y.
Gernert, Marvin L.....Kingsport, Tenn
Gerrard, John S.....Ahmadi, Kuwait, Persian Gulf
Gerson, Frederick T.....New Southgate, London, N. 11, England
Gettys, Wilbur H..Bartlesville, Okla.
Gibbon, Anthony.....Tulsa, Okla.
Gibbons, Harry J.....Tulsa, Okla.
Gifford, Edmund W.....Milwaukee, Wis.
Gilbert, T. H....Los Angeles, Calif.
Gilliams, Francis B.....Philadelphia, Pa.
Gilliland, John L., Jr.....Denver, Colo.
Gilmore, Ernest A., Jr.....Wichita, Kan.
Givens, Allen T.....Monroe, La.
Glandon, G. O.....Tulsa, Okla.
Glasgow, Clarence O....Tulsa, Okla.
Glass, D. C.....Chicago, Ill.
Gleason, Alvin T....Shreveport, La.
Glenn, Denis....Wichita Falls, Tex.
Gleser, Sol M.....St. Louis, Mo.
Glidden, William E...Pitman, N. J.
Godard, H. P.....Kingston, Ontario, Canada
Godfrey, John W....Lockport, N. Y.
Godshalk, James B.....Philadelphia, Pa.
Godshall, J. Byron.....Easton, Pa.
Goebel, Eugene S.....Chicago, Ill.
Goetz, Alvin C.....Cincinnati, Ohio
Goit, Laurance E.....Los Angeles, Calif.
Goldsby, Fred L....New York, N. Y.
Goldkamp, Chris A.....San Diego, Calif.
Good, Donald Blake....Tulsa, Okla.
Goodall, R. A.....Ogallala, Neb.
Goodman, E. E....Granite City, Ill.
Goodrich, C. R....Fort Worth, Tex.
Goodwin, Carlton L., Portland, Me.
Goodwin, James M...Somerset, Ohio
Goodyear, Mark.....Olean, N. Y.
Gorden, C. D.....Katy, Tex.
Gorman, L. J.....New York, N. Y.
Gosnell, Everett C...Cleveland, Ohio
Goudielock, Wm. B. O'Brien.....New York, N. Y.
Gow, James T.....Portland, Ore.
Gowans, Louis L...Honolulu, T. H.
Graber, Waldo E.....Liberal, Kan.
Grader, K. W.....Philadelphia, Pa.
Grandi, Ing. Alberto...Milan, Italy
Grant, Wheeler H.....Laredo, Tex.
Grassman, Herbert S..Oak Park, Ill.
Grau, Vicente Massuet.....Barcelona, Spain
Graves, Colburn R.....Long Island, N. Y.
Graves, J. H.....Joinerville, Tex.
Graves, John W.....Shreveport, La.
Graves, R. W.....Shreveport, La.
Gray, A. E.....Elizabeth, N. J.
Gray, R. M.....Long Beach, Calif.
Greathouse, Glenn A.....Washington, D. C.
Grebe, H. A.....Houston, Tex.
Grebe, John J.....Midland, Mich.
Greber, A. C.....Cincinnati, Ohio
Grebinar, Herbert L.....New York, N. Y.
Grebstad, Ernest H.....Los Angeles, Calif.
Greco, Edward C....Shreveport, La.
Green, Donald R..Kalamazoo, Mich.
Green, W. A.....Little Rock, Ark.
Green, Willis G., Los Angeles, Calif.
Greene, John F., Jr..Barber, N. J.
Greene, U. T.....Painesville, Ohio
Gregg, Harris T.....Houston, Tex.
Gregory, Milton W.....Waterville, Ohio
Gribble, Charles G., Jr.....Houston, Tex.
Griffin, Everett M.....Birmingham, Ala.
Griffin, H. K.....Meridian, Miss.
Griffith, Darrel F.....Houma, La.
Griffith, Dean O.....Houston, Tex.
Griffith, T. E.....Houston, Tex.
Griggs, Henry P..Silver Spring, Md.
Griswold, T. N...Ponca City, Okla.
Grizzard, Eugene H.....Los Angeles, Calif.
Grondal, B. J.....Belmont, Mass.
Groom, Claude H.....Tulsa, Okla.
Gropp, Armin H....Gainesville, Fla.
Gross, Lewis.....McAllen, Tex.
Gross, W. F.....St. Louis, Mo.
Grounds, Leo R.....Houston, Tex.
Groves, Ken D.....Chicago, Ill.
Gruber, K. A.....New York, N. Y.
Guenther, Paul R....Buffalo, N. Y.
Guerry, Wm. A..Little Silver, N. J.
Guinn, C. F.....Houston, Tex.
Gumm, Howard W....Houston, Tex.
Gurney, W. B.....Baton Rouge, La.
Guthrie, John M....Swissvale, Pa.

H

Haas, Charles A.....Houston, Tex.
Haas, D. Marshall...Baytown, Tex.
Haas, Nields B.....Corapolis, Pa.
Haas, W. B.....Omaha, Neb.
Haase, Harold F....Milwaukee, Wis.
Hackerman, Norman...Austin, Tex.
Hackett, Albert Harold.....Caracas, Venezuela, S. A.
Haddad, Ibrahim Sami.....Beirut, Lebanon
Hadley, Raymond F.....Philadelphia, Pa.
Haering, Vera W..San Antonio, Tex.
Hagemeier, Charles E.....Houston, Tex.
Hager, Frederick.....Elmira, Ontario, Canada
Hager, Karl F.....Huntsville, Ala.
Hagerman, Charles W.....Philadelphia, Pa.
Hagius, Karl S.....Colorado Springs, Colo.
Hagstad, Andrew..New York, N. Y.
Hahler, John J., Jr.....North Platte, Neb.
Hahn, A. H.....Tulsa, Okla.
Halbig, John J....Middletown, Ohio
Hale, Robert L., Jr.....Lake Charles, La.
Hale, William L., Brooklyn, N. Y.
Hall, Elwin B...Los Angeles, Calif.
Hall, George D.....Houston, Tex.
Hall, Kenneth G....Elizabeth, N. J.
Hall, Marvin F...Washington, D. C.
Hall, Nathaniel.....Newark, N. J.
Hall, R. E.....Rolling Hills, Calif.
Hall, W. Quentin, Baton Rouge, La.
Hall, William A...Philadelphia, Pa.
Halley, James W.....East Chicago, Ind.
Halsell, Hampton L.....Fayetteville, Ark.
Halsted, Hal F.....Altadena, Calif.
Haltom, J. Myrl.....Dallas, Tex.
Hamann, Charles E.....West Lynn, Mass.
Hamilton, Archer B.....Hartford, Conn.
Hamilton, Hugh L.....Philadelphia, Pa.
Hamilton, J. S.....New Kensington, Pa.
Hamilton-Smith, A....Abadan, Iran
Hamlin, Arthur W.....New York, N. Y.
Hammond, Milton B.....Edgeworth Sewickley, Pa.
Hamstead, A. C.....South Charleston, W. Va.
Hancock, Charles W....Tulsa, Okla.
Hanes, Henry W..Jacksonville, Tex.
Haney, Charles E.....San Francisco, Calif.
Hansen, Tolbert L.....Dhahran, Saudi Arabia
Hanson, Melvin A.....Bloomington, Ill.
Happ, Charles R..Port Arthur, Tex.
Harbison, Dixon T.....Fort Worth, Tex.
Harden, Gail D...East Chicago, Ind.
Hardman, James T....Tulsa, Okla.
Hardy, Ivan C.....Ottawa, Ontario, Canada
Hargroder, A. D..Lake Charles, La.
Harker, Thomas W.....Morton Grove, Ill.
Harnsberger, A. E....Chicago, Ill.
Harris, Jack W.....Houston, Tex.
Harris, John J.....Houston, Tex.
Harrison, Gordon D.....Knoxville, Tenn.
Harrison, James R...Newark, Ohio
Hart, James L...Bartlesville, Okla.
Hart, M. B.....Brookfield, Ill.
Hart, Porter.....Freeport, Tex.
Hart, R. P.....St. Louis, Mo.
Hart, Stanley W.....St. Louis, Mo.
Hartley, Harry A...Cleveland, Ohio
Hartman, H. F.....Baytown, Tex.
Hartman, Lowell S...St. Louis, Mo.
Hartwell, Richard R., Maywood, Ill.
Hartwick, Otto J.....Houston, Tex.
Harvey, C. C.....Baton Rouge, La.
Harvey, John M.....Tulsa, Okla.
Harvey, W. J.....Newark, N. J.
Harwood, Julius J.....Washington, D. C.
Haskins, Frank D.....Flint, Mich.
Hatch, George B...Pittsburgh, Pa.
Hatchett, V. W.....Augusta, Kan.
Hatfield, Homer F...Allentown, Pa.
Hausman, John C...Harrisburg, Pa.
Hawke, David L...Brooklyn, N. Y.
Hayner, Donald L..Milwaukee, Wis.
Haynes, Harold J..New Orleans, La.
Healey, Edward Lewis.....Sayville, N. Y.
Heath, John R.....Cleveland, Ohio
Hecht, Max.....Drexel Hills, Pa.
Heck, Stanley M.....Reading, Pa.
Hedborg, Carl E.....Wilmington, Calif.
Hedges, Eugene B...Saginaw, Mich.
Heger, J. J.....Pittsburgh, Pa.
Heideman, William A.....East St. Louis, Ill.
Heil, Carl E.....Cleveland, Ohio
Heinemann, Gustave.....Corpus Christi, Tex.
Heinen, Lawrence E..Houston, Tex.
Heinzerling, Robert F.....Hasbrouck Heights, N. J.
Heiss, Franklin S. D.....Philadelphia, Pa.
Heitman, Talmage M., Jr.....Houston, Tex.
Helmbrecht, A. J., New York, N. Y.
Helmrath, Norman K.....Chicago Heights, Ill.
Hemphill, D. B.....Odessa, Tex.
Henderson, E. L...Shreveport, La.
Henderson, Mervin W.....Springfield, Mo.
Henderson, Oliver ...Cleveland Ohio
Henderson, W. Paul, Baltimore, Md.
Henderson, Walter A.....New York, N. Y.
Hendrickson, David..Oakland, Calif.
Henke, Robert H.....Brackenridge, Pa.
Henley, Don J....Port Neches, Tex.
Henry, Ernest L.....Bellaire, Tex.
Henry, R. E.....Longview, Tex.
Herberg, William F., Jr.....Houston, Tex.
Herman, Theodore H., Jr.....Washington, D. C.
Herringshaw, D. E.....Jackson, Mich.
Herrmann, Hans.....Newark, N. J.
Hersam, G. Russell..New York, N. Y.
Herstein, F. E.....Plainfield, N. J.
Herzler, Ralph E., Jr., Chicago, Ill.
Herzog, Max A.....Springfield, Mo.
Hess, Albert W.....Camden, N. J.
Hess, Fred E.....Fort Worth, Tex.
Hess, W. T.....New Orleans, La.

Heussner, Carl E.....Birmingham, Mich.
Heverly, L. F.....Kansas City, Mo.
Hewitt, Harry N.....Montreal, Quebec, Canada
Hibbs, Don B.....Kansas City, Mo.
Hickethier, Carlos F.....Republic, Argentina, S. A.
Hickey, Robert P...Trenton, Mich.
Hieronymus, Frantz M., Tulsa, Okla.
Hiers, George O.....Brooklyn, N. Y.
Higburg, Wm. ....Indianapolis, Ind.
Higdon, Victor E.....Wilmington, Calif.
Higgins, Edward J.....East Orange, N. J.
Higgins, Howard L....Lorain, Ohio
Higgins, J. D., Jr.....Fort Worth, Tex.
Higgins, Waldo W....Kankakee, Ill.
Hill, George R.....Salt Lake City, Utah
Hill, J. Ernest.....Fairfield, Ala.
Hill, Leonard C.....Hastings, Neb.
Hill, Roy W.....Fort Belvoir, Va.
Himmelrich, John Earle.....Pittsburgh, Pa.
Himmler, Alden C., Hollywood, Md.
Hinchman, William H. D.....Detroit, Mich.
Hinckley, Arthur T.....Niagara Falls, N. Y.
Hinds, Julian...Los Angeles, Calif.
Hirshfeld, James F...Detroit, Mich.
Hodson, Fred W.....Corpus Christi, Tex.
Hoiberg, Arnold J., El Dorado, Ark.
Holcomb, William D...Chicago, Ill.
Holcombe, Tom L., Shreveport, La.
Holler, Homer D..Chevy Chase, Md.
Holloway, J. A.....Edna, Tex.
Holm, Emil G.....Houston, Tex.
Holmberg, Emil G.....Linden, N. J.
Holmberg, M. E., Bartlesville, Okla.
Holmes, Laird E.....Robinson, Ill.
Holsteyn, Derk.....Houston, Tex.
Holt, James B.....Dallas, Tex.
Holtman, Clemens W.....Louisville, Ky.
Holtzscher, George A., Jr.....Granite City, Ill.
Honecker, Walter C.....Indianapolis, Ind.
Honkala, H. E.....Decatur, Ala.
Hookanson, Kenneth G.....Morton Grove, Ill.
Hopkins, Arthur James.....Melbourne, Australia
Hopkins, James L...Columbus, Ohio
Hopkins, John R.....Denver, Colo.
Hopkins, W. H.....Houston, Tex.
Hopper, Edward W.....Pittsburgh, Pa.
Horne, Albert N...Beirut, Lebanon
Horst, Ralph L., Jr.....New Kensington, Pa.
Horstman, W. G.....Atlanta, Ga.
Hort, Percy.....Philadelphia, Pa.
Horton, James B....Bethlehem, Pa.
Horvath, Louis.....Cleveland, Ohio
Hose, Alfred G.....Cleveland, Ohio
Hosford, Harry W., Cleveland, Ohio
Howald, Thomas S.....Euclid, Ohio
Howard, Owen G.....Toledo, Ohio
Howell, John C...Maplewood, N. J.
Howell, R. P., San Francisco, Calif.
Hoxeng, Raymond B.....Cleveland, Ohio
Hoyt, W. B.....New York, N. Y.
Huber, Karl E...Long Beach, Calif.
Huckleberry, S. A.....Corpus Christi, Tex.
Hudachek, Raymond J.....Hot Springs Nat'l. Park, Ark.
Huddleston, Charles E., Jr.....Beaumont, Tex.
Huddleston, Wm. E.....Bartlesville, Okla.
Hudock, George W.....Park Forest, Ill.
Hudson, George H., Jr.....Los Angeles, Calif.
Hudson, Willis I.....Houston, Tex.
Hughes, Charles F.....Port Arthur, Tex.
Hughes, D. E., Jr.....Houston, Tex.
Hughes, H. D.....Dallas, Tex.
Hughes, H. M.....Tulsa, Okla.
Hugo, L. A.....Bartlesville, Okla.
Hulcy, Louis B.....Dallas, Tex.
Hull, George C., Jr...Newark, N. J.
Humble, H. A.....Midland, Mich.
Hummon, C. Gerald.....Kansas City, Mo.
Hunt, A. J.....Odessa, Tex.
Hunter, Felix A.....Sweeny, Tex.
Hunter, J. N., Jr.....Tulsa, Okla.
Hunter, Ralph M....Midland, Mich.
Huntley, Harold R.....New York, N. Y.
Hur, J. James....Philadelphia, Pa.
Hurley, E. T.....Montreal, Quebec, Canada
Hurst, Ralph.....Jackson, Miss.
Hurst, S.....London, England, N.W. 11
Hurtado, J. R.....Caracas, Venezuela, S. A.
Hurtgen, Archibald, Louisville, Ky.
Huseby, Robert A...Milwaukee, Wis.
Husock, Bernard....Cleveland, Ohio
Hustead, B. G.....Kilgore, Tex.
Huston, Kenneth M..Baltimore, Md.
Hutchcraft, D. K.....Olean, N. Y.
Hutchinson, Carroll O., Chicago, Ill.
Hutchinson, Gilbert E.....Bridgeport, Conn.
Hutchison, John S.....Tulsa, Okla.
Huth, Eugene G.....Cleveland, Ohio
Hutzler, George J.....Philadelphia, Pa.

I

Iderstine, Robert Van.....Rochester, N. Y.
Imhoff, Carroll E...Milwaukee, Wis.
Ingels, G. R.....Houston, Tex.
Ingham, Herbert S.....Long Island City, N. Y.
Ireland, L. G.....New Orleans, La.
Irwin, C. A.....Brownsville, Tex.
Isherwood, J. H.....Port Allegany, Pa.
Isles, Frederick W....Linden, N. J.

J

Jackson, C. M.....Newark, N. J.
Jackson, J. Harry..Columbus, Ohio
Jackson, Maynard H...Tulsa, Okla.
Jackson, Russell.....Phoenix, Ariz.
Jackson, Willis E.....Toledo, Ohio
Jacobek, Warren G.....Forest Park, Ill.
Jacobson, Murray .....Watertown, Mass.
Jacobson, Ralph N.....San Francisco, Calif.
James, H. E.....Jackson, Miss.
James, Jay R.....Tulsa, Okla.
James, Paul W.....Syracuse, N. Y.
James, Wm. D....Port Arthur, Tex.
Janny, Louis.....Paris, France
Janota, Rudolph B.....Chicago, Ill.
Jednacz, John E...Philadelphia, Pa.
Jeffares, George M....Atlanta, Ga.
Jehu, Llewellyn, Jr.....Lachine, Quebec, Canada
Jekot, Chester M.....Chicago, Ill.
Jelen, Frederic C....Syracuse, N. Y.
Jelinek, F. R.....Port Neches, Tex.
Jenkins, Clark L....Houston, Tex.
Jenkins, Vance N.....Wilmington, Calif.
Jenner, William C.....Cleveland, Ohio
Jennings, Carl H..Fort Worth, Tex.
Jensen, Claude H....Glassport, Pa.
Jensen, M. G.....Toledo, Ohio
Jensen, O. L.....Oak Park, Ill.
Jessen, Frank W.....Austin, Tex.
Jewell, James G.....Pittsburgh, Pa.
Joecks, Adolph K..New York, N. Y.
Johannes, E. Gent...St. Louis, Mo.
Johns, Donald H.....St. Louis, Mo.
Johnsen, Walter .....Staten Island, N. Y.
Johnson, Carl R...New York, N. Y.
Johnson, Carl V...Philadelphia, Pa.
Johnson, Dewey W....Chicago, Ill.
Johnson, Earl A. N., Shelton, Wash.
Johnson, Elmer A....Lincoln, Calif.
Johnson, Gerald M., Ft. Worth, Tex.
Johnson, Herbert S.....Shawinigan Falls, Quebec, Canada
Johnson, J. F., Jr., Zionsville, Ind.
Johnson, R. K.....New York, N. Y.
Johnson, Robert L...Jackson, Mich.
Johnson, Robert T....Freeport, Tex.
Johnson, Thomas E....Freeport, Ill.
Johnson, W. A.....Melbourne, C. 1, Vic. Australia
Johnson, Walter C..Columbus, Ohio
Johnson, Wayne A....Houston, Tex.
Johnson, Wm. W.....Port Arthur, Tex.
Johnston, Howard E.....New York, N. Y.
Johnston, J. Flynn....Atlanta, Ga.
Johnston, Thomas A., Jr.....Charlotte, N. C.
Jones, Charles C...Philadelphia, Pa.
Jones, David T.....North Hollywood, Calif.
Jones, Elmer H., Los Angeles, Calif.
Jones, G. C.....Jackson, Miss.
Jones, Jesse C...Newport News, Va.
Jones, R. M.....Chicago, Ill.
Jones, William E.....Dixon, Ill.
Jopp ,J. M.....La Tuque, Quebec, Canada
Jorczak, Joseph S....Trenton, N. J.
Jordan, Harry E.....New York, N. Y.
Jordan, Melvin N.....Kermit, Tex.
Jordan, Philip R...Mishawaka, Ind.
Jordan, Raymond C.....Shreveport, La.
Jorgensen, Roy C....Freeport, Tex.
Joy, Austin S...Wilmington, Calif.
Joyce, Edwin .....Dallas, Tex.
Judah, Melvin A.....Houston, Tex.
Juppenlatz, John W...Lebanon, Pa.
Jurs, Peter C.....Berkeley, Calif.
Juster, Maurice W.....East Chicago, Ind.

K

Kahler, H. Lewis, Philadelphia, Pa.
Kahler, Leroy P..Jersey City, N. J.
Kahn, Frank.....Philadelphia, Pa.
Kahn, Walter C., Jr.....New York, N. Y.
Kaim, Fred J....Minneapolis, Minn.
Kalhauge, Viggo M.....Chicago, Ill.
Kamps, Julius M....Pittsburgh, Pa.
Karger, Frank S.....Chicago, Ill.
Karraker, E. L....Waltham, Mass.
Kartinen, Ernest O.....Los Angeles, Calif.
Kaster, J. W.....Tulsa, Okla.
Kaszynski, John F.....Chicago, Ill.
Kauffman, David S.....Independence, Kan.
Kaufman, L. W....Mansfield, Ohio
Kaufmann, D. W....Buffalo, N. Y.
Kavenaugh, J. A.....Los Angeles, Calif.
Kayser, James N.....North Baton Rouge, La.
Kean, E. E., Jr.....Columbus, Miss.
Keane, C. C.....Kansas City, Mo.
Keaney, J. C.....Pittsburgh, Pa.
Keaton, Lawrence C....Borger, Tex.
Kedzie, Donald P.....Houston, Tex.
Keeling, Harry J.....Los Angeles, Calif.
Keepers, Guy S.....Enid, Okla.
Keeton, T. E...Corpus Christi, Tex.
Kehn, G. Ray.....Orange, Tex.
Keith, Cecil S...Grand Prairie, Tex.
Keller, A. V.....Gering, Neb.
Kellam, G. D.....Calgary, Alberta, Canada
Keller, Albert Freed, Baltimore, Md.
Keller, Ralph W.....Colorado City, Tex.
Keller, Richard M.....Philadelphia, Pa.
Keller, W. H.....St. Louis, Mo.
Kelley, John H.....Baltimore, Md.
Kellogg, Andrew....Syracuse, N. Y.
Kelly, Howard M.....Boston, Mass.
Kelly, R. W.....Tulsa, Okla.
Kelly, Thomas F. P., Houston, Tex.
Kelly, Warner M.....Houston, Tex.
Kemp, James T.....San Francisco, Calif.
Kemper, E. O.....Odessa, Tex.
Kendall, Verner V...Pittsburgh, Pa.
Kendrick, J. L.....Kenner, La.
Kennedy, Carl M....Springfield, Ill.
Kennedy, Harvey T.....College Station, Tex.
Kennedy, Ted....Ann Arbor, Mich.
Kerns, Everette E...Cleveland, Ohio
Kerschner, Edward .....Philadelphia, Pa.
Kessler, Kenneth K..Baltimore, Md.
Ketcham, Brower .....San Francisco, Calif.
Kettron, Henry P.....MacComb, Ill.
Keyt, Ernest B...El Segundo, Calif.
Kiefer, George C., Brackenridge, Pa.
Kierstein, Norman A..Detroit, Mich.
Kilberg, Bernard.....Moline, Ill.
Kimbro, A. M.....Houston, Tex.
Kimen, Peter A.....Pasadena, Tex.
Kimmel, Albert L.....Gainesville, Fla.
King, Robert J....Richmond, Calif.
Kinley, John C.....Houston, Tex.
Kinnear, R. C....Port Neches, Tex.
Kinney, Wayne L.....Chicago, Ill.
Kipp, E. M.....New Orleans, La.
Kirkendall, William E.....Los Angeles, Calif.
Klauber, L. M.....San Diego, Calif.
Kleber, John P.....Pittsburgh, Pa.
Kleefisch, William...St. Louis, Mo.
Kleespies, Henry S., Jr.....Port Arthur, Tex.
Klein, Fred. M....New York, N. Y.
Klein, James C.....Owensboro, Ky.
Klein, Meyer.....Houston, Tex.
Klinger, John C.....Houston, Tex.
Kleinheksel, S.....Plainfield, N. J.
Klever, Charles F.....Omaha, Neb.
Klinger, Lloyd L.....Wisconsin Rapids, Wis.
Klinger, O. C.....Bayonne, N. J.
Klopp, Edward M...Cleveland, Ohio
Kluender, Arnold F....Chicago, Ill.
Klumb, George H...Northbrook, Ill.
Klumb, Harvey J...Rochester, N. Y.
Knapp, Frederick F.....Glendive, Mont.
Knight, C. A.....Beaumont, Tex.
Knopp, Harold P....Oakland, Calif.
Knowlton, A. E...New York, N. Y.
Knowlton, Drexel R...Avenal, Calif.
Koeckritz, E. Paul, Jr.....Los Angeles, Calif.
Koehler, W. A.....Morgantown, W. Va.
Koenig, E. A.....Shreveport, La.
Koester, H. F.....New York, N. Y.
Kolff Van Oosterwijk, A. R.....Amsterdam, Holland
Kolzow, Clarence R...Elmhurst, Ill.
Kopetz, Geo. E.....Pittsburgh, Pa.
Kopp, C. H....Oklahoma City, Okla.
Koppl, Frederick.....Chicago, Ill.
Kosik, John A...Chattanooga, Tenn.
Krch, Milford F...San Diego, Calif.
Krell, A. J.....Houston, Tex.
Kretschmer, Wm. J..Columbus, Ohio
Krickl, Joseph L., Jr..Maywood, Ill.
Krikscus, Paul, Jr.....Los Angeles, Calif.
Krochmalski, Edward .....Corning, N. Y.
Kroon, Harry E.....Chicago, Ill.
Kropf, Victor J.....East Pittsburgh, Pa.
Krueger, Forrest J.....New York, N. Y.
Krueger, Jess J.....Beatrice, Neb.
Krueger, Louis T.....Casper, Wyo.
Kruger, R. E.....Rochester, N. Y.
Kruszynski, Edward A.....St. Louis, Mo.
Krystow, Paul....Jersey City, N. J.
Kuehnle, C. A., Jr...Baltimore, Md.
Kuhlmann, Frank H., St. Louis, Mo.
Kuhn, Cyril D.....Houston, Tex.
Kuhn, Robert J...New Orleans, La.
Kulman, Frank E., New York, N. Y.
Kuniansky, I.....Atlanta, Ga.
Kunz, Earl F.....Cleveland, Ohio

L

Lachmund, D. O.....Newark, N. J.
Lacy, J. Glen....South Gate, Calif.
Ladd, Glenn L.....Tulsa, Okla.
Ladd, Raymond J....Midland, Mich.
LaFever, Mortier, Jr.....Washington, D. C.
Lain, George D....New York, N. Y.
Lambert, Frank J., Jr.....Oak Ridge, Tenn.
Lamm, Kenneth L...Jackson, Mich.
Lane, B. S.....Kalamazoo, Mich.
Lane, Russell W.....Champain, Ill.
Lang, Albert A.....Cleveland, Ohio
Lang, Frances S...New York, N. Y.
Lang, Franklin...New York, N. Y.
Langhans, Oscar.....Harvey, La.
LaQue, F. L.....New York, N. Y.
Larrabee, C. P.....Vandergrift, Pa.
Larson, John A.....Evanston, Ill.
Larson, Thurston E....Urbana, Ill.
Laster, Gaines.....Tulsa, Okla.
Lastrapes, Richard L.....Beaumont, Tex.
Lattin, Benton Calver.....Mt. Vernon, N. Y.
Lautner, Robert B.....Baton Rouge, La.
Lavery, C. A.....Tulsa, Okla.
Law, John E.....Oak Park, Ill.
Law, R. J.....Toronto, Canada
Lawall, Russell M....Oberlin, Ohio
Lawlor, E. W.....Tulsa, Okla.
Lawrence, J. C....Twinsburg, Ohio
Lawrence, R. E., Jr., Tarboro, N. C.
Lawson, J. M.....Lamont, Ill.
Lawton, Ledra M...Lockport, N. Y.
Lay, Albert F.....Houston, Tex.
Layne, Harold B.....Colorado City, Tex.
Leary, John D., Corpus Christi, Tex.
Leas, A. Robert..Washington, D. C.
Le Blanc, Roland L..Maplewood, La.
Lebrecht, G. Frank...St. Louis, Mo.
Lecourt, Stanley M.....New Orleans, La.
Ledbetter, Buford P.....Corpus Christi, Tex.
Lederer, Lewis M., Cincinnati, Ohio
Ledford, Robert C.....Houston, Tex.
Lee, B. C., Jr.....Norfolk, Va.
Lee, Bertrand Edward, Sr.....Atlanta, Ga.
Lee, Charles E...Los Angeles, Calif.
Lee, R. P.....South Amboy, N. J.
Lee, Robert H.....Indianapolis, Ind.
Leedom, Laurie M.....Bloomfield, N. J.
Lefebvre, Fabian J...Newark, N. J.
Lehmann, Frederick A.....Oak Ridge, Tenn.
Lehmann, Joseph A.....New York, N. Y.
Leister, John A.....Pittsburgh, Pa.
Lemay, Jack E.....Pittsburgh, Pa.
Lembcke, Richard E., Tallant, Okla.
Lemcke, E. M.....Houston, Tex.
Leonardon, Eugene Gilbert.....Houston, Tex.
Leonhard, Frederick J.....Cleveland, Ohio
Lepley, Raymond D.....Philadelphia, Pa.
Lester, C. B.....Longview, Tex.
Lester, L. B....Los Angeles, Calif.
Levert, Wm. F....Shreveport, La.
Levinson, Irving S.....Milwaukee, Wis.
Levy, David Henry.....Dallas, Tex.
Lewis, L. G.....Midland, Tex.
Lewis, Robert H.....Fort Lauderdale, Fla.
Lewis, Walter T.....Houston, Tex.
Liebhafsky, Herman A.....Schenectady, N. Y.
Liebman, Arno J....Pittsburgh, Pa.
Liggett, Ernest J.....Tulsa, Okla.
Ligon, John R....Fort Worth, Tex.
Lima, D. O....Oklahoma City, Okla.
Lindberg, Jay G.....Provo, Utah

Lindberg, R. I.....Harvey, Ill.
Lindemann, Ervin .....Minneapolis, Minn.
Lineback, George A.....Cincinnati, Ohio
Lingle, Robert J.....Bellaire, Tex.
Lithgow, James, Los Angeles, Calif.
Littreal, Wm. Bernard.....Salt Lake City, Utah
Livengood, Robert G.....Shreveport, La.
Lobley, F. A.....Elkhart, Ind.
Lobo, Humberto, Jr.....Monterrey, N. L., Mexico
Lobry De Bruyn, C. A.....Delft, Holland
Locke, Giles.....Youngstown, Ohio
Lockeman, George F.....Cincinnati, Ohio
Lockheed, E. W.....Houston, Tex.
Lockwood, C. J.....Beaumont, Tex.
Lockwood, Luther E...Maywood, Ill.
Loeffler, John Edward.....Houston, Tex.
Loeffler, William J.....Providence, R. I.
Logan, Kirk H...Washington, D. C.
Lomax, O. Q.....Houston, Tex.
Long, Dan P.....Amarillo, Tex.
Long, Frank V., Sr.....Compton, Calif.
Loos, De Lasso.....Midland, Tex.
Lopata, Stanley L....St. Louis, Mo.
Lopez, Eugene R., New York, N. Y.
Lo'Prete, Jack H.....Detroit, Mich.
Loucks, Charles M., Cleveland, Ohio
Loudenback, Clyde I....Chicago, Ill.
Love, Billy Ray.....Carrizo Springs, Tex.
Love, Frank H.....Dallas, Tex.
Loveladv, H. A.....Tulsa, Okla.
Lovoi, Frank J.....Houston, Tex.
Lovell, Odus W., Jr.....Shreveport, La.
Lowe, Marvin E.....Bogota, Colombia, S. A.
Lowe, R. A., Maracaibo, Venezuela
Lowerre, R. T.....Cleveland, Ohio
Lowther, G. B.....St. Louis, Mo.
Loyd, Clyde C.....Baton Rouge, La.
Luce, Walter A.....Dayton, Ohio
Luger, Karl E.....Houston, Tex.
Lundberg, H. E....Stamford, Conn.
Lundy, Daniel A.....Los Angeles, Calif.
Lungren, E. E.....Chicago, Ill.
Lutjens, Fred H....Sioux City, Iowa
Lutsch, William A....Detroit, Mich.
Lynch, Robert H., Philadelphia, Pa.
Lynch, William H....St. Louis, Mo.
Lynes, Wilson.....Rome, N. Y.
Lyon, John A. M.....Evanston, Ill.

M

MacCollum, Donald R.....Rochester, N. Y.
MacCormack, Robert S., Jr.....Mountain Lakes, N. J.
MacDonald, A. John..Houston, Tex.
MacDonald, Frank P...Chicago, Ill.
MacGregor, Alfred H.....Webster Groves, Mo.
Mach, Walter W.....Wichita, Kan.
Machado, Oscar .....Caracas, Venezuela, S. A.
MacKenzie, James T.....Birmingham, Ala.
Madden, R. C.....Fontana, Calif.
Maddigan, S. E.....Vancouver, B. C., Canada
Madero, Carlos F.....Monterrey, Mexico
Magoffin, Linn E.....National City, Calif.
Maguire, Chester G., Sr.....Fairfield., Ill.
Maher, D. W.....Detroit, Mich.
Mahoney, E. J., Jr...Lansing, Mich.
Main, Merrill M.....Chicago, Ill.
Maitland, T. J.....New York N. Y.
Malcom, V. V.....Cincinnati, Ohio
Maloney, Eugene E...Buffalo, N. Y.
Maloney, Richard W.....Los Angeles, Calif.
Malouf, E. E., Salt Lake City, Utah
Mandley, John O.....Detroit, Mich.
Mange, Clarence E...St. Louis, Mo.
Manley, Harold W.....Tulsa, Okla.
Mann, L. D.....Lake Charles, La.
Manning, John A., Jr.....Galveston, Tex.
Manning, Paul D. V...Chicago, Ill.
Maraudin, Alexei P.....El Segundo, Calif.
Markham, Wendell G.....Long Beach, Calif.
Markle, M. G.....Oak Park, Ill.
Marlin, Donald H...Pittsburgh, Pa.
Marrinan, J. W.....Pittsburgh, Pa.
Marshall, Dwight...New York, N. Y.
Marshall, George W.....Lennoxville, Quebec, Canada
Marshall, Robert P.....Ferndale (Detroit), Mich.
Martin, Arthur R., Milwaukee, Wis.
Martin, D. S....Indianapolis, Ind.
Martin, Jack T...New Orleans, La.
Martin, Paschal.....Chicago, Ill.
Martin, Robert C.....Atlanta, Ga.
Marx, Paul F.....Bradford, Pa.
Mason, John F., Jr.....New York, N. Y.
Mason, John R.....Tulsa, Okla.
Massing, Robert W.....Chicago, Ill.
Mathers, W. D.....Ridgefield, N. J.
Matheson, E. E.....Pittsburgh, Pa.
Matson, Eugene M.....Chicago, Ill.
Matthews, Norman A...Elyria, Ohio
Matthews, R. F.....Tulsa, Okla.
Mauney, L. M.....Tulsa, Okla.
Maurer, Robert F...Wood River, Ill.
Mavor, James E.....Houston, Tex.
Maw, J. T.....Cartagena, Columbia, South America
May, Thomas P...New York, N. Y.
Mayer, George H.....Dallas, Tex.
Mayer, William J., Baltimore, Md.
Mayer, Wm. M..Corpus Christi, Tex.
Mayes, Edward .....San Francisco, Calif.
Mayes, H. B.....Houston, Tex.
Mayo, E. E...San Francisco, Calif.
McAnneny, Adrian W.....Houston, Tex.
McArthur, Ralph F.....Huntington Park, Calif.
McCall, Richard H....Houston, Tex.
McCallum, Walter C., Jr.....Maplewood, La.
McCammon, G. A.....Caracas, Venezuela, S. A.
McCann, Sidney W.....Rochester, N. Y.
McCarthy, Robert A....Dallas, Tex.
McCaslin, Kenneth M.....South Gate, Calif.
McCauley, E. D...Birmingham, Ala.
McClenahan, W. T.....Chicago, Ill.
McClintock, Robt. D...Detroit, Mich.
McCloud, Dwite M.....La Habra, Calif.
McClughan, Joseph...Houston, Tex.
McCluskey, Francis J.....St. Louis, Mo.
McComas, John Q....Hamilton, Ohio
McComb, Geo. B.....St. Louis, Mo.
McConnel, Fred M.....Los Angeles, Calif.
McConomy, Henry F.....Philadelphia, Pa.
McCormick, Lawrence O.....Baltimore, Md.
McCullough, Harold M.....Bayside, Long Island, N. Y.
McCutcheon, C. Alan.....St. Davids, Pa.
McDaniel, John P.....Houston, Tex.
McDonald, Angus N..Louisville, Ky.
McDonald, Herschel C.....San Antonio, Tex.
McDonald, Lawrence L.....Chicago, Ill.
McDonald, T. B.....Shreveport, La.
McDuffie, Roy O...Cincinnati, Ohio
McElhatton, Francis J.....Kansas City, Mo.
McElroy, Charles R..Buffalo, N. Y.
McEntire, Eldon T.....Salt Lake City, Utah
McEwen, Cecil R.....Paducah, Ky.
McFarland, Rolland, Jr.....Chicago, Ill.
McGary, S. U.....Houston, Tex.
McGeary, Frank L.....New Kensington, Pa.
McGee, Herbert S.....Evanston, Ill.
McGee, W. C.....Houston, Tex.
McGowan, Benjamin I., Jr.....Baltimore, Md.
McGowan, James A.....Los Angeles, Calif.
McGrue, W. M.....Brentwood, Mo.
McIlrath, Samuel W.....Painesville, Ohio
McIntosh, Russell W.....Los Angeles, Calif.
McIntyre, G. H...Cleveland, Ohio
McKain, George D...Louisville, Ky.
McKee. Arvil B.....New Kensington, Pa.
McKenney, Warren E..Houston, Tex.
McKenzie, T. Curtis.....Dearborn, Mich.
McLaren, James...Oak Ridge, Tenn.
McMahon, George F....Chicago, Ill.
McManus, John J..Edgewater, N. J.
McMillan, W. A., Jr.....Waxahachie, Tex.
McMullin, H. I.....Dallas, Tex.
McNeil, Edwin B..Baton Rouge, La.
McNeill, John B.....Chicago, Ill.
McNulty, Frank E....Tulsa, Okla.
McRaven, C. H., Cocoli, Canal Zone
McSparran, W. G.....Los Angeles, Calif.
McWaters, Raymond J.....Long Island City, N. Y.
McWethy, Gilbert A.....Kalamazoo, Mich.
McWhorter, Sam B.....New Brunswick, N. J.
Meacher, H. John..Cincinnati, Ohio
Mead, William J.....Hutton Park, West Orange, N. J.
Means, Ben H.....Houston, Tex.
Meany, John J., Jr...Newark, N. J.
Mears, Robert B....Pittsburgh, Pa.
Meek, J. Gordon.....Dallas, Tex.
Meglemre, Robert W.....Bessemer, Ala.
Meier, Alfred O....New York, N. Y.
Meigs, W. H., Oklahoma City, Okla.
Menaul, Paul L.....Tulsa, Okla.
Mendive, Anthony J., Houston, Tex.
Mendizza, August .....Murray Hill, N. J.
Menefee, Wm. F.....Wichita Falls, Tex.
Mengel, Arthur C.....Schenectady, N. Y.
Mensch, Ralph G....Bridgeville, Pa.
Mentzel, Sigmund T.....Gary, Ind.
Mercer, C. L.....Houston, Tex.
Merrill, Harry E....Buffalo, N. Y.
Merrill, Timothy W.....Bridgeville, Pa.
Merwin, Walter J.....Chicago, Ill.
Meyer, Frederick R.....New Haven, Conn.
Meyer, Philip A...New York, N. Y.
Meyer, Walter.....St. Louis, Mo.
Michael, Lewis E.....Dayton, Ohio
Michaud, M. L...Wilmington, Calif.
Mikesell, William H....Chicago, Ill.
Milas, Alfred B...Birmingham, Ala.
Miles, John A.....Diablo Heights, Canal Zone
Miller, Carl F., Jr.....Philadelphia, Pa.
Miller, Dwight L..Wyandotte, Mich.
Miller, Harry J.....Chicago, Ill.
Miller, John J.....Pittsburgh, Pa.
Miller, M. C...W. Englewood, N. J.
Miller, Pat H.....Shreveport, La.
Miller, Paul Thomas..Houston, Tex.
Miller, Ralph D....Pittsburg, Kan.
Miller, Ross F....Emeryville, Calif.
Miller, W. S.....Baltimore, Md.
Miller, William J.....Chicago, Ill.
Mills, Earnest J.....Benton, La.
Mills, Geo. A...Corpus Christi, Tex.
Mills, James L.....Rouseville, Pa.
Mills, Lester D., Jr., Cleveland, Ohio
Mills, Richard P.....Freedom, Pa.
Miltner, Richard E....Wichita, Kan.
Minor, Alton F.....Jackson, Miss.
Mitchell, E. B.....Houston, Tex.
Mitchell, Francis H.....Los Angeles, Calif.
Mitchell, Leo S.....Pasadena, Tex.
Mitchell, Malcom..Indianapolis, Ind.
Mitchell, Marvin G....Tulsa, Okla.
Mitchell, N. W....Waterbury, Conn.
Mock, Guy C.....Houston, Tex.
Moe, John L..Flushing, L. I., N. Y.
Moehrl, Kenneth E..Memphis, Tenn.
Moffatt, Thomas S., Jr.....Corpus Christi, Tex.
Moffett, J. L.....Lima, Ohio
Moffitt, John H.....Hugoton, Kan.
Moir, B. E.....Dallas, Tex.
Moncrief, R. S.....Shreveport, La.
Monson, Louis T.....Los Angeles, Calif.
Montague, Donald E...Detroit, Mich.
Montel, Joseph I....Jamacia, N. Y.
Montgomery, Allen M.....Cleveland, Ohio
Moore, Albert E.....Camden, N. J.
Moore, H. W.....Tulsa, Okla.
Moore, Jack M.....Midland, Tex.
Moore, Laban T...Catlettsburg, Ky.
Moore, Orville E....Zionsville, Ind.
Moore, Roy W.....Brooklyn, N. Y.
Moorman, Earl F.....Chicago, Ill.
Moran, Joseph H.....Buffalo, N. Y.
Moran, W. T.....Houston, Tex.
Morgan, C. L.....Houston, Tex.
Morgan, T. A.....Houston, Tex.
Morgan, Zane V.....Seguin, Tex.
Mori, John Y.....Chicago, Ill.
Morris, Clarence S.....Los Angeles, Calif.
Morris, H. E.....Texas City, Tex.
Morris, James I.....Worland, Wyo.
Morrison, Barclay.....Union N. J.
Morrison, D. B.....Gary, Ind.
Morrison, John G..Philadelphia, Pa.
Morrow, Orville E.....San Francisco, Calif.
Morse, Arley Edwin...Chicago, Ill.
Morse, Robert E...New York, N. Y.
Morton, Byron B...New York, N. Y.
Moseley, E. L.....Houston, Tex.
Mosher, Malcolm.....Quincy, Mass.
Moss, Charles F., Jr.....Wilmington, Del.
Mount, W. R....City of Edmonton, Edmonton, Alberta, Canada
Moyar, Robert E.....Pendopo, Sumatra, Indonesia
Moyer, Fred.....Chicago, Ill.
Moyer, George H.....Chicago, Ill.
Moyle, M. W.....Rosita, Coahuila, Mexico
Mudd, O.....Houston, Tex.
Muery, Sam J., Jr.....Port Sulphur, La.
Mulheran, Bernard C.....Cleveland, Ohio
Muller, Herman, Jr.....New York, N. Y.
Mullin, Grover E., Philadelphia, Pa.
Mullins, Sidney O.....Gary, Ind.
Mulvanev. E. J., Jr., Pasadena, Tex.
Mundt, H. W.....Diablo Heights, Canal Zone
Munger, C. G.....South Gate, Calif.
Munroe, D. D.....Oakmont, Pa.
Murphy, G. J. W.....Bellaire, Tex.
Murray, Christopher A.....Nederland, Tex.
Murray, Herman D..Ft, Smith, Ark.
Murrey, O. E.....Tulsa, Okla.
Muschenheim, Harry, Jr.....Philadelphia, Pa.
Myers, G. Frank....Beaumont, Tex.
Myers, W. R.....Wilmington, Del.

N

Naschke, John H....Houston, Tex.
Nash, William F., Jr.....Alhambra, Calif.
Neal, Jas. L.....Dallas, Tex.
Neal, Robert W...Fort Worth, Tex.
Nee, John W...Corpus Christi, Tex.
Nee, Robert M.....Tulsa, Okla.
Neher, Frank H...New York, N. Y.
Neilon, C. R.....Houston, Tex.
Neipp, Howard S., Kansas City, Mo.
Nelson, Alan C.....Beruit, Lebanon
Nelson, F. M.....Houston, Tex.
Nelson, H. Lloyd.....Baldwin Park, Calif.
Nelson, Harry....Bartlesville, Okla.
Nelson, Loyd B.....Cushing, Okla.
Neprude, E. N., Minneapolis, Minn.
Nerhood, H. Elmer.....Akron, Ohio
Neuhoff, Paul S.....Monsanto, Ill.
Nevill, Richard A., Ft. Worth, Tex.
Newell, I. Laird...Hartford, Conn.
Newland, Stewart H..Boston, Mass.
Newport, John J.....Freeport, Tex.
Newton, William E.....Lakewood, Ohio
Nichols, Alfred.....Detroit, Mich.
Nichols, Laurie E.....Oak Park, Ill.
Nichols, P. E.....Galveston, Tex.
Nicholson, C. T.....Buffalo, N. Y.
Nicholson, J. C.....Tulsa, Okla.
Nicholson, Jay T.....Los Angeles, Calif.
Nickell, J. F.....Tulsa, Okla.
Nickerson, James G..Lafayette, La.
Nickle, F. Verne....Cleveland, Ohio
Nieliwocki, Louis M....Orange, Tex.
Nielsen, Claudius....Detroit, Mich.
Nielsen, Norman A.....Wilmington, Del.
Niwao, Jitsuo, Hilo, Hawaii, T. H.
Nixon, James A.....New Haven, Conn.
Nolan, James C..Los Angeles, Calif.
Nolan, Vincent J..New York, N. Y.
Nole, Vito F.....Waterbury, Conn.
Noppel, E. P.....New York, N. Y.
Norberg, H. A.....Tulsa, Okla.
Nord, G. L.....Cincinnati, Ohio
Nordquist, Howard O.....St. Louis, Mo.
Norris, J. M....Wichita Falls, Tex.
Northup, M. S.....Linden, N. J.
Norton, Harry A...Kansas City, Mo.
Norwood, Vincent M.....Petrolia, Ontario, Canada
Noser, W. P.....Houston, Tex.
Noss, Oscar F., Jr.....Long Beach, Calif.
Notley, Charles K....Oakland, Calif.
Noyes, A. P.....Kilgore, Tex.
Nuezel, E. F.....Cincinnati, Ohio

O

Obermann, Walter..Belleville, N. J.
O'Brien, Harold C., Jr.....Blawnox, Pa.
O'Brien, H. L., East Chicago, Ind.
O'Brien, Paul S...Baton Rouge, La.
O'Brien, Thos. W.....South Field Station, Detroit, Mich.
O'Connell, Frank D...St. Louis, Mo.
O'Connor, James R..Pottstown, Pa.
Odell, L. B.....Houston, Tex.
Odom, William A.....Lafayette, La.
Oechsle, Robert W.....Philadelphia, Pa.
Ogburn, H. R.....Marshall, Tex.
Ogden, James A.....Van, Tex.
O'Keefe, John F...New York, N. Y.
O'Leary, F. J., Beverly Hills, Calif.
Olive, Marion J.....Shreveport, La.
Oliver, J. Paul.....Cleveland, Ohio
Olson, G. R.....Shreveport, La.
Olson, Theodore W...Wharton, Tex.
Oravetz, Julius A.....Racine, Wis.
Orchard, E. L..Corpus Christi, Tex.
Osborn, Oliver..Lake Jackson, Tex.
Osterloh, Frederick V.....Freeport, Tex.
Ott, Lawrence H., South Gate, Calif.
Ott, Robert J.....Philadelphia, Pa.
Ottolenghi, Mario L.....New York, N. Y.
Oxford, W. F., Jr...Beaumont, Tex.
Oxley, George W....Elizabeth, N. J.

P

Pace, Anderson, Jr.....Chicago, Ill.
Page, Glenn I.....Tulsa, Okla.
Paige, Henry.....Philadelphia, Pa.
Palmer, James G.....Sharon, Pa.
Palmquist, William W.....Cleveland, Ohio

Park, Paul S., Jr., Pittsburgh, Pa.
Parker, Ivy M.....Bremen, Ga.
Parker, Kenneth B.....Philadelphia, Pa.
Parker, Marshall E., Jr.....Houston, Tex.
Parnell, H. S.....Jackson, Miss.
Parr, James M.....Houston, Tex.
Parr, MacGregor A...Houston, Tex.
Parran, J. Harold...Baltimore, Md.
Parrish, Worden W.....Olney, Ill.
Parson, R. A.....Hammond, Ind.
Partington, Sydney...Detroit, Mich.
Patrick, George M...Houston, Tex.
Patterson, Bryan .....Salt Lake City, Utah
Patterson, M. Kingsley.....Minneapolis, Minn.
Paul, Robert J.....Cincinnati, Ohio
Payne, Paul P....Indianapolis, Ind.
Payne, Harrison S.....San Francisco, Calif.
Payson, Peter.....Harrison, N. J.
Payton, Victor J.....Chicago, Ill.
Peabody, A. W.....Jackson, Miss.
Peard, James C....Scottsbluff, Neb.
Pearson, E. T.....Maplewood, N. J.
Pearson, John M...Swarthmore, Pa.
Peifer, Norman P., Pittsburgh, Pa.
Peifer, Richard H.....Library, Pa.
Peirce, Walter A.....Racine, Wis.
Pellegrino, Frank M.....Philadelphia, Pa.
Pelton, Charles H.....Clinton, Iowa
Pendergast, Hugh W.....Beverly Hills, Calif.
Penland, William R..St. Louis, Mo.
Pennington, Louis E...Tulsa, Okla.
Perier, Claude H.....Los Angeles, Calif.
Perkins, Wendell L.....New York, N. Y.
Permar, Philip H..Wilmington, Del.
Perrault, Lewis.....Tulsa, Okla.
Perrett, William R.....Vicksburg, Miss.
Perry, Joe Reddell....El Paso, Tex.
Perry, Russell I.....Chicago, Ill.
Peterkin, Don W.....Chicago, Ill.
Peters, Fred P....New York, N. Y.
Peters, Ralph C., Philadelphia, Pa.
Peters, Wilbur Ralph, Jr.....Poughkeepsie, N. Y.
Petersen, Charles W..Beatrice, Neb.
Petersen, Lowell W....Chicago, Ill.
Peterson, A. J.....Chicago, Ill.
Peterson, Erle V...Wilmington, Del
Peterson, F. P., Jr.....Corpus Christi, Tex.
Peterson, John C.....Gibsonia, Pa.
Petras, George R.....Chicago, Ill.
Petruschka, Max..Jerusalem, Israel
Pettee, Allen D.....Perth Amboy, N. J.
Pettibone, John S.....Philadelphia, Pa.
Pettijohn, Dale S....Burrton, Kan.
Petty, Ralph G.....Mexia, Tex.
Pettyjohn, A. R....Texas City, Tex.
Pettyjohn, E. S.....Chicago, Ill.
Pfeiffer, Milton J..Cincinnati, Ohio
Pfrehm, Raymond H.....Corpus Christi, Tex.
Phelps, H. S.....Philadelphia, Pa.
Phelps, Samuel C.....Tulsa, Okla.
Phillians, T. F...Los Angeles, Calif.
Phillips, Cecil, Jr....Baytown, Tex.
Phillips, Edwin H.....Oak Park, Ill.
Phillips, James H....Alliance, Ohio
Phillips, Kenneth A.....East St. Louis, Ill.
Phillips, Preston D., Jr.....Houston, Tex.
Phillips, William D....Chicago, Ill.
Phillians, T. F..Los Angeles, Calif.
Phipps, Harry K....Wichita, Kan.
Picarazzi, Joseph J.....Lake Charles, La.
Pickens, Andrew T.....East St. Louis, Ill.
Pickering, Harry S....Miami, Fla.
Pickrell, David D.....Ranger, Tex.
Pickup, Lester R.....Los Angeles, Calif.
Pierce, E. K. Ted....Houston, Tex.
Pierce, Edgar M.....Boston, Mass.
Pierce, Robert R., Philadelphia, Pa.
Pietrzak, Aloysius J.....Philadelphia, Pa.
Pike, Donald R.....Boston, Mass.
Pike, Vernon B..Murray Hill, N. J.
Pinner, W. L.....Detroit, Mich.
Pirsh, Edward A., New York, N. Y.
Pittman, Charles U.....Westfield, N. J.
Pittman, James H., Jr..Odessa, Tex.
Pittman, William G.....Hackensack, N. J.
Place, George W., New York, N. Y.
Plant, A. Morton.....New Haven, Conn.
Platz, E. H., Jr.....Lebanon, Pa.
Pliner, Leon M.....Shreveport, La.
Ploederl, Francis J..Hamilton, Ohio
Plog, Charles B., New York, N. Y.
Plym, Lester M.....Chicago, Ill.
Pogacar, C. F.....Pittsburgh, Pa.
Pokorny, Jerome J., Cleveland, Ohio
Polhamus, John R.....Corpus Christi, Tex.
Pollard, T. A.....Dallas, Tex.
Pollitt, L. Irving, Jr.....Long Branch, N. J.
Pollock, Bill...Corpus Christi, Tex.
Pollock, Carl D.....Seattle, Wash.
Polston, J. R.....Tulsa, Okla.
Pomeroy, Richard..Pasadena, Calif.
Pool, John L.....Dallas, Tex.
Poole, Charles I.....Midland, Tex.
Pope, Robert.....Quakertown, Pa.
Porson, Allan B...New York, N. Y.
Porter, Fred B....Fort Worth, Tex.
Post, J. H. G., The Hague, Holland
Potteiger, William I., St. Louis, Mo.
Potts, John.....Dallas, Tex.
Pourbaix, M. J....Brussels, Belgium
Powell, Edwin B.....Boston, Mass.
Powell, Sheppard T., Baltimore, Md.
Power, Pierce H.....Long Island City, N. Y.
Powers, Merle T...Murphysboro, Ill.
Powers, Stanley C.....Akron, Ohio
Powers, William J., Coatesville, Pa.
Pracy, George W.....San Francisco, Calif.
Prange, Frederick A.....Bartlesville, Okla.
Pratt, Ward E.....Harrison, N. J.
Pray, H. A.....Columbus, Ohio
Prescott, Joseph....Cleveland, Ohio
Presley, Maurice C.....Waterbury, Conn.
Price, Marion E.....Golden, Colo.
Price, Walter J.....Houston, Tex.
Priestley, Henry L..New York, N. Y.
Prime, Joseph B., Jr...Miami, Fla.
Prince, Arthur E..New York, N. Y.
Prior, Joseph E.....Mantua, N. J.
Pritchett, Edward C....Atlanta, Ga.
Procter, Bryant S., Jr.....Cleveland, Ohio
Proctor, B. L...Corpus Christi, Tex.
Proskowitz, Seymour..Bronx, N. Y.
Prutton, C. F.....Baltimore, Md.
Puckett, George J..Pittsburg, Calif.
Purdy, D. F.....Los Angeles, Calif.
Purdy, George E.....St. Louis, Mo.
Purton, T. A...Salt Lake City, Utah
Pyeatt, F. E., Jr.....Tulsa, Okla.
Pyles, Russell.....Olean, N. Y.
Pyott, William T.....Calgary, Alberta, Canada

Q

Quale, James D.....Pittsburgh, Pa.
Quimby, W. S....New York, N. Y.
Quinlan, Joseph F.....Schenectady RDI, N. Y.

R

Radcliffe, Thomas Drew.....Evanston, Ill.
Radovich, Frank .....North Hollywood, Calif.
Rafsnider, Lowell B.....Columbus, Ohio
Raifsnider, Philip J.....Emeryville, Calif.
Raigorodsky, Paul M.....Houston, Tex.
Rainey, John B.....Houston, Tex.
Raith, W. H.....St. Louis, Mo.
Rall, Richard A., Jr.....Los Angeles, Calif.
Rambaldi, Elio.....Naples, Italy
Range, E. C.....Atlanta, Ga.
Rankin, Elbert L.....Corpus Christi, Tex.
Ransom, R. A....Washington, D. C.
Ranta, Leo G.....Chicago, Ill.
Raphael, William.....Boston, Mass.
Rapp, Harry E.....Pittsburgh, Pa.
Rask, Morris L.....Shaker Heights, Ohio
Rasmussen, V. L....St. Louis, Mo.
Rasor, John P....San Gabriel, Calif.
Ray, Edward B.....Midland, Tex.
Rayner, Reid L.....Detroit, Mich.
Read, Harold J., State College, Pa.
Reading, Robert E.....Dallas, Tex.
Rector, Paul F.....Houston, Tex.
Reeb, Fred C., Corpus Christi, Tex.
Reed, C. Espy....New Orleans, La.
Reed, Clyde L.....Chicago, Ill.
Reed, John W.....Ferndale, Mich.
Reed, Paul S.....Tulsa, Okla.
Reed, Ramsey M., Birmingham, Ala.
Reese, Max.....Gravville, Ill.
Reeves, B. M.....Marshall, Tex.
Reeves, Frank E...Baton Rouge, La.
Reichard, Edmund C., Barber, N. J.
Reid, J. C.....Dallas, Tex.
Reid, Keith, K.....New Kensington, Pa.
Reinhard, Herbert W.....Newtonville, Mass.
Reinhardt, G. A.....Youngstown, Ohio
Reinhardt, Wm., Los Angeles, Calif.
Reinhart, Fred M.....Silver Spring, Md.
Renshaw, William G.....Brackenridge, Pa.
Rhodes, Edmund O..Pittsburgh, Pa.
Rhodes, H. A.....Houston, Tex.
Riall, Lindsey W....Shreveport, La.
Rice, E. L.....St. Louis, Mo.
Rice, Francis T.....Chicago, Ill.
Rice, R. J.....Houston, Tex.
Rice, S. S.....Mansfield, Ohio
Rice, William R.....Houston, Tex.
Rich, Newton D.....Chicago, Ill.
Richard, Charles S.....North Plainfield, N. J.
Richards, David O....Newark, Ohio
Richards, S. L., Jr....Houston, Tex.
Richardson, James L..Houston, Tex.
Richardson, John I.....South Gate, Calif.
Ricksecker, Ralph E.....Cleveland, Ohio
Riddick, Thomas M.....New York, N. Y.
Riddle, H. S....Charleston, W. Va.
Ridenour, Charles A.....Beaumont, Tex.
Riegel, G. M.....Massillon, Ohio
Ries, William J.....St. Louis, Mo.
Rifenburgh, Arthur W.....St. Louis, Mo.
Rigo, Jane H. M....Cleveland, Ohio
Riley, Robert F.....Miami, Fla.
Rimbach, Richard...Pittsburgh, Pa.
Rimbault, E. L., Jr.....New York, N. Y.
Ringer, Francis...Downington, Pa.
Rio, Anthony J.....Chicago, Ill.
Riordan, M. B., Los Angeles, Calif.
Riordan, Maurice A...Houston, Tex.
Rios, Juan Rios.....Havana, Cuba
Riseling, T. M.....Oklahoma City, Okla.
Ritchie, Robert .....Pointe-A-Pierre, Trinidad, B. W. I.
Robb, Edward H....Buffalo, N. Y.
Robbins, John T., New York, N. Y.
Robbins, Kenneth W..Houston, Tex.
Roberson, Frank.....Gary, Ind.
Roberti, Giorgio.....Rome, Italy
Roberts, John K....Pittsburgh, Pa.
Roberts, John P.....Houston, Tex.
Roberts, L. J.....Amarillo, Tex.
Roberts, R. G.....Chicago, Ill.
Robeson, Ralph M.....Los Angeles, Calif.
Robinson, Harold A.....Midland, Mich.
Robinson, John L....Midland, Mich.
Robinson, T. J.....Houston, Tex.
Robinson, Vincent D.....New York, N. Y.
Robison, Walter L., Cleveland, Ohio
Robson, Arthur D.....Staten Island, N. Y.
Roddey, O. C.....Monroe, La.
Roddy, David F.....Denison, Tex.
Roden, Harry....Port Neches, Tex.
Roesler, Ewald A.....Houston, Tex.
Roessing, Earl F....Columbus, Ohio
Rogers, James F.....Mantua, Ohio
Rogers, John A.....Tulsa, Okla.
Rogers, Oscar F....Waukegan, Ill.
Rogers, R. R.....Ottawa, Canada
Rogers, Walter F.....Houston, Tex.
Rogerson, J. B....El Dorado, Ark.
Rogness, E. C....San Diego, Calif.
Rohrman, F. A.....Boulder, Colo.
Rohrman, Robert W.....Maplewood, La.
Rohwedder, John L.....Rock Island, Ill.
Rolfs, E. L.....Houston, Tex.
Roll, Kempton H., New York, N. Y.
Romell, Robert F...Cincinnati, Ohio
Romig, O. E.....Pittsburgh, Pa.
Rondeau, H. S.....Shaker Heights, Ohio
Roosa, Max B.....Detroit, Mich.
Root, Wesley B., Jr.....Baton Rouge, La.
Rose, Gordon P., Sr...Detroit, Mich.
Rose, W. A.....Houston, Tex.
Rosenthal, Morris.....El Paso, Tex.
Ross, Anthony...Youngstown, Ohio
Ross, Culbertson W.....Washington, D. C.
Ross, George T.....Houston, Tex.
Ross, Kenneth B.....Abadan, South Iran
Ross, Sterling L.....Arlington Heights, Ill.
Rosselle, Douglass T....Miami, Fla.
Rosson, J. H., Jr.....Corpus Christi, Tex.
Rothrock, E. S.....Houston, Tex.
Routson, L. B.....Cincinnati, Ohio
Rowe, Hartley.....Boston, Mass.
Royston, John H.....Blawnox, Pa.
Royston, Louis G....Blawnox, Pa.
Royston, Thos. T....Blawnox, Pa.
Rozelle, W. W..Salt Lake City, Utah
Rudolf, Henry T...Jacksonville, Fla.
Rue, Edward C.....Boston, Mass.
Ruffing, Frank M....Trenton, Ohio
Rupf, J. Albert.....Wichita, Kan.
Rupp, Earl V.....Chicago, Ill.
Rush, E. H.....East Chicago, Ind.
Russell, G. I.....Chatham, Ontario, Canada
Russell, John C.....Albuquerque, N. M.
Rutemiller, Herbert C.....Cleveland, Ohio
Rutherford, John J. B.....Beaver Falls, Pa.
Rutledge, Collie C., Jr.....Shreveport, La.
Rutter, Charles M., Jr.....Pittsburgh, Pa.
Rydell, Robert G.....Chicago, Ill.
Ryznar, J. W.....Chicago, Ill.

S

Sage, John F.....Tulsa, Okla.
Saia, Anthony.....Houston, Tex.
Saigh, N. A....San Antonio, Tex.
Salmon, Philip A....Newark, N. J.
Sample, Clarence H.....New York, N. Y.
Sandberg, John H....Houston, Tex.
Sandel, Walter J...Lakewood, Ohio
Sanders, Irvin C.....Independence, Kan.
Sanders, W. S., Jr.....Washington, D. C.
Sanderson, Wiley D., Detroit, Mich.
Sandor, John G....Cleveland, Ohio
Sands, George A...New York, N. Y.
Sanford, Robert D....St. Louis, Mo.
Santschi, William H.....Tarentum, Pa.
Sargent, John E.....Tulsa, Okla.
Satz, Leo H.....Schenectady, N. Y.
Saul, Edgar R.....New York, N. Y.
Saulson, Paul.....Detroit, Mich.
Savage, Robert H.....Los Angeles, Calif.
Scamman, Chas. W...Houston, Tex.
Scanlon, D. A.....Cleveland, Ohio
Scarola, V. J.....New York, N. Y.
Scarpa, Oscar .....Da Vinci 32, Milan, Italy
Schaefer, Ralph A.....Cleveland, Ohio
Schauers, Joseph A.....Philadelphia, Pa.
Scheibelhut, Clement H.....LaGrange, Ill.
Scheil, Merrill A...Milwaukee, Wis.
Scherer, Lewis F....Houston, Tex.
Schereschewsky, P. D.....Paris, France
Schiff, Melvin J.....Newark, N. J.
Schilling, W. M.....Bell, Calif.
Schlather, Max F.....San Antonio, Tex.
Schlaudt, Clarence A...Trona, Calif.
Schlossberg, Louis .....Conshohocken, Pa.
Schmeeckle, Duane A.....Donaldsonville, La.
Schmid, Charles F...Seymour, Conn.
Schmidt, Herbert W.....Midland, Mich.
Schmidt, J. M., Los Angeles, Calif.
Schmidt, Jacob B.....Los Angeles, Calif.
Schmidt, R. W...Lake Jackson, Tex.
Schmidt, R. W.....Sierra Madre, Calif.
Schmierer, A. F....Beatrice, Neb.
Schmitz, Carl Edward, Chicago, Ill.
Schmitz, Fred W.....Terre Haute, Ind.
Schmuck, Howard K., Jr.....Houston, Tex.
Schneider, John H.....Whitefish Bay, Wis.
Schneider, Wm. R.....Emeryville, Calif.
Schoene, C. E.....St. Louis, Mo.
Schofer, Nathan...New York, N. Y.
Schor, Milton.....Chester, Pa.
Schreiner, William J.....Cincinnati, Ohio
Schreitz, Wm. Gordon.....Annapolis, Md.
Schroth, Charles R.....Haddon Heights, N. J.
Schroth, Harry A., Glendive, Mont.
Schueler, Robert C.....Bishop, Tex.
Schuh, A. E.....Burlington, N. J.
Schuhmacher, Gordon S.....South Gate, Calif.
Schultz, R. F....Wilmington, Del.
Schupp, Carleton H., Westwego, La.
Schutt, Russell W.....Franklin, La.
Schwemlein, Wm. .....Parkersburg, W. Va.
Scott, F. L.....Carteret, N. J.
Scott, Glenn C.....Houston, Tex.
Scott, Gordon N..Los Angeles, Calif.
Scott, Harold H....Martinez, Calif.
Scott, T. C.....Kokomo, Ind.
Scott, Thomas W.....Odessa, Tex.
Scribner, Leonard...Lake Bluff, Ill.
Scull, William L.....Colorado Springs, Colo.
Seagren, G. W.....Pittsburgh, Pa.
Seal, Wm. D.....Indianapolis, Ind.
Seal, Reed E.....Cleveland, Ohio
Searcy, John E., Jr..Shreveport, La.
Searer, Jay C.....North Tonawanda, N. Y.
Seath, John .....Buckingham, Quebec, Canada
Secrest, Leslie C., Ponca City, Okla.
Segel, Kalman .....Aruba, Netherland Antilles
Seidel, G. E.....Chicago, Ill.
Seidenstricker, R. A.....Milwaukee, Wis.

Seidman, Stanley M. Cleveland, Ohio
Seifried, Dean B. Spring Valley, N. Y.
Seivert, M. A. Los Angeles, Calif.
Selle, Joseph B. Houston, Tex.
Sellers, H. P. Houston, Tex.
Senatoroff, N. K. Los Angeles, Calif.
Serbula, Steve, Jr. Chicago, Ill.
Serenco, Harvey St. Louis, Mo.
Serven, Edward J., Jr. Clifton, N. J.
Severance, Wesley A. Cleveland, Ohio
Sevin, Lloyd L. New Orleans, La.
Seyl, Robert G. Evanston, Ill.
Seymour, Arthur H. Argo, Ill.
Seymour, Raymond B. Mertztown, Pa.
Shackelford, Robert E., Tulsa, Okla.
Shanahan, J. P. St. Louis, Mo.
Share, Martin Chicago, Ill.
Sharpe, L. G. Houston, Tex.
Sharpnack, E. V. Louisville, Ky.
Shaw, A. G. New York, N. Y.
Shaw, George E. Houston, Tex.
Shaw, George S. Shawinigan Falls, P. Q., Canada
Shaw, William E. Niagara Falls, N. Y.
Sheard, Walter G., Jr. Freeport, N. Y.
Sheets, Earl T. Newport, Ark.
Sheets, Macon Corpus Christi, Tex.
Sheldahl, David B. Harvey, Ill.
Shellenbarger, Wilbur D. Toledo, Ohio
Shelton, M. J. La Mesa, Calif.
Shelves, Arthur R. Chicago, Ill.
Shemilt, Leslie W. Vancouver, Canada
Shenton, F. George Monroeville, N. J.
Shepard, Arthur P. Flushing, Long Island, N. Y.
Shepard, E. R. Washington, D. C.
Shepard, Harry L. Houston, Tex.
Shepard, Spencer W. New York, N. Y.
Sheppard, Joseph E. Cleveland, Ohio
Sheppard, Lyle R. Houston, Tex.
Sherer, Clayton M. Holtwood, Pa.
Sheridan, Richard W. Tulsa, Okla.
Sherwood, B. C. Chicago, Ill.
Sherwood, William C. South Boston, Mass.
Shideler, Norman T. Allison Park, Pa.
Shields, James E. Niagara Falls, N. Y.
Shigley, C. M. Freeport, Tex.
Shipman, Waldo A. Charleston, W. Va.
Shnidman, Louis Rochester, N. Y.
Shoan, Raymond A. Chicago, Ill.
Shobe, E. H., Corpus Christi, Tex.
Shobe, O. F. Cleveland, Ohio
Shock, D. A. Ponca City, Okla.
Shoor, Abraham Haifa, Israel
Short, Howard E. Cincinnati, Ohio
Shoumatoff, Nicholas New York, N. Y.
Shuldener, Henry L. New York, N. Y.
Shultz, S. T. Ras El Mishaab, Saudi Arabia
Shupp, Carl W. Los Angeles, Calif.
Sibley, Robert S. St. Louis, Mo.
Siddall, D. F. Akron, Ohio
Sidwell, C. V. Tulsa, Okla.
Siebert, C. A. Ann Arbor, Mich.
Siegel, Edward S. Baldwin, N. Y.
Siekmann, John F. Chicago, Ill.
Sievert, M. A. Los Angeles, Calif.
Sill, George H. Philadelphia, Pa.
Sills, T. O., Sr. Kannapolis, N. C.
Sime, Robert M., Washington, D. C.
Simmons, Edward E., Jr. Pasadena, Calif.
Simmons, Julius M. Fort Wayne, Ind.
Simon, Allan Harrison, N. J.
Simons, Gordon F. Reading, Pa.
Simpson, A. D., Jr. Houston, Tex.
Simpson, John B. Jackson, Mich.
Simpson, N. H. Fort Worth, Tex.
Sims, C. I. Dallas, Tex.
Sims, Chester T. Marble Cliff, Columbus, Ohio
Sittel, V. J. Tulsa, Okla.
Skafte, Stanley F. Arcadia, Calif.
Skeie, Kermit Chicago, Ill.
Skinner, Edmond N., Jr. New York, N. Y.
Skog, Ludwig, Jr. Chicago, Ill.
Slavik, Edward W. New Orleans, La.
Sline, Louis L. Houston, Tex.
Slough, Ralph M. Findlay, Ohio
Small, Richard B. Beverly Hills, Calif.
Smith, A. V. Bala-Cynwyd, Pa.
Smith, Alonzo L. Houston, Tex.
Smith, Alvis F. Minneapolis, Minn.
Smith, Arthur B. Jacksonville, Fla.
Smith, Bertram M. Los Angeles, Calif.
Smith, Carl B. Chicago, Ill.
Smith, Carl M. Houston, Tex.
Smith, Clair J., Bakersfield, Calif.
Smith, Claude B. San Francisco, Calif.
Smith, Don C. Port Arthur, Tex.
Smith, H. D., Halifax, N. S. Canada
Smith, Harold L., Kansas City, Mo.
Smith, James M. Shreveport, La.
Smith, Joseph W. Chicago, Ill.
Smith, Lyle R. Ogallala, Neb.
Smith, Martin B. Pasadena, Calif.
Smith, Nowery J. Houston, Tex.
Smith, O. R. Fort Worth, Tex.
Smith, Philip H. St. Louis, Mo.
Smith, Randal E. Carlsbad, N. M.
Smith, Rex L. Tulsa, Okla.
Smith, Robert J. Chicago, Ill.
Smith, Robert M. Houston, Tex.
Smith, Sidney V. Houston, Tex.
Smith, Sydney S. New York, N. Y.
Smith, Tracy E. Dallas, Tex.
Smith, Turner C. Los Angeles, Calif.
Smith, Vaughn R. Richmond, Calif.
Smith, Vernon R. Long Island, N. Y.
Smith, Walter R. Buffalo, N. Y.
Smith, Walter W. Cleveland, Ohio
Smith, Wm. B., Jr., Shreveport, La.
Smith, Wm. Furber. Hoboken, N. J.
Smith, William E., Jr. Cleveland, Ohio
Smith, William N. Peru, Ill.
Snashall, Earl H. Columbus, Ohio
Snedaker, Delbert G. Wichita Falls, Tex.
Snell, Clark A. New York, N. Y.
Snider, Henry I. Southgate, Calif.
Snyder, B. W. Calgary, Alberta, Canada
Snyder, Fred B. Alliance, Ohio
Snyder, Frederick Joseph. Venice, Calif.
Snyder, Kenneth T. Houston, Tex.
Snyder, Louis A. Wilmington, Calif.
Soape, Ross Houston, Tex.
Sospin, H. A. Jenkintown, Pa.
Southern, Charles M. Port Arthur, Tex.
Sowards, George Findlay, Ohio
Spafford, Perry Parker. Houston, Tex.
Spalding, D. A. Midland, Mich.
Spalding, James C., Jr. Dallas, Tex.
Spangenberg, Robert F. West Allis, Wis.
Sparks, Robert E. Port Hueneme, Calif.
Spector, Dov Tel-Aviv, Isarel
Speller, Frank N., Pittsburgh, Pa.
Spencer, L. S. Houston, Tex.
Spencer, S. F. Philadelphia, Pa.
Spinks, Lee N. Shreveport, La.
Spoehr, Thomas F. Morton Grove, Ill.
Spooner, Leonard G., Jr. Carteret, N. J.
Stafford, Allen D. Houston, Tex.
Stalker, Marion H. Los Angeles, Calif.
Stanley, Alfred H. Chicago, Ill.
Stanton, W. L. Shreveport, La.
Staples, Wm. R. Union, N. J.
Starbird, L. C. Dallas, Tex
Stark, Conrad. Wellsville, N. Y.
Statham, Tom R. Dallas, Tex.
Stauffacher, E. R. Los Angeles, Calif.
Stearns, D. E. Shreveport, La
Stearns, Ned C. Shreveport, La.
Steel, Edward W. Pittsburgh, Pa.
Stegner, A. L. Houston, Tex.
Stein, Walter F. G. Pampa, Tex.
Steinberger, Chester. Houston, Tex.
Steiner, Robert H. Mertztown, Pa.
Stelzer, James G. Jackson, Mich.
Stephan, Dean E. Los Angeles, Calif.
Stephens, E. H. Wichita, Kan.
Stephens, Foster M. Los Angeles, Calif.
Stephens, Robert A. Easton, Pa.
Stephens, Thomas O. South Gate, Calif.
Stephenson, G. W. Corpus Christi, Tex.
Stephenson, James F., Houston, Tex.
Stephenson, R. B. Dayton, Ohio
Stericker, William Upper Darby, Pa.
Stern, Milton Cambridge, Mass.
Sterne, Cecil M. Long Island City, N. Y.
Sterrett, Elton Houston, Tex.
Stevens, Ward W. Monroe, La.
Stevenson, John M. Dallas, Tex.
Stevenson, Kenyon, Jr. Philadelphia, Pa.
Stewart, Alex New York, N. Y.
Stewart, C. A. New Orleans, La.
Stewart, Edwin L. New York, N. Y.
Stewart, William Fred, Tulsa, Okla.
Stewart, W. H. Beaumont, Tex.
Stiers, Vernon E. Beaverton, Ore.
Stilgenbauer, N. T. Tulsa, Okla.
Stirling, J. C. Tulsa, Okla.
Stitt, James R. Detroit, Mich.
Stivers, F. A. Tulsa, Okla.
Stobaugh, Robert B., Jr. Caripito, Monagas, Venezuela, S. A.
Stobie, John J., Jr. Chicago, Ill.
Stockhausen, Frank H. Milwaukee, Wis.
Stoertz, Howard. Philadelphia, Pa.
Stokes, William S. Huntington Park, Calif.
Stone, J. M. Wilmington, Del.
Storm, Arthur E. Associated, Calif.
Story, E. B. Ambridge, Pa.
Stott, Tom Morton Grove, Ill.
Strachan, John F. London, E. C. 2, England
Strader, William P. Dayton, Ohio
Strange, Harold T. Mobile, Ala.
Strawn, Lynn Rudolph Port Neches, Tex.
Streever, Otis J. Newport News, Va.
Streicher, Lee Laverne, Calif.
Streit, Frank H. Columbus, Ohio
Strom, C. F. Newark, N. J.
Stromquist, Russell C. Pittsburgh, Pa.
Stromsoe, Douglas A. Azusa, Calif.
Strothman, E. P. Chicago, Ill.
Struben, Frederik J., Jr. Houston, Tex.
Stuart, Linden, Jr. Plainfield, N. J.
Stuart, Paul S., Jr. New Orleans, La.
Studer, Fred R. Wilmington, Del.
Stull, Fred D. Memphis, Tenn.
Sturrock, Murray G. Pittsburgh, Pa.
Stutzman, Milo J., Kansas City, Mo.
Sudrabin, Leon P. Newark, N. J.
Sullivan, David N. Atlanta, Ga.
Sullivan, E. H. Shreveport, La.
Sutherlin, James E. Rahway, N. J.
Sutter, Carl H. Wichita, Kan.
Suverkrop, E. A. Trenton, N. J.
Svetlik, Joseph Hammond, Ind.
Svrchek, Joseph G. Chicago, Ill.
Swanbeck, Leonard W. St. Jacob, Ill.
Swann, J. S. Hammond, Ind.
Swanson, A. R. Atlanta, Ga.
Sward, G. G. Washington, D. C.
Swartout, C. W. St. Louis, Mo.
Sway, Boris Cincinnati, Ohio
Swensson, Stuart J. Pittsburgh, Pa.
Swindoll, Robert E. Jackson, Miss.
Sybert, Jack H. Midland, Tex.

T

Tait, Emmitte P. Atlanta, Ga.
Talbott, Daniel W. Hillside, N. J.
Talmey, Paul Chicago, Ill.
Tamez, Oscar Vazquez Tampico, Tam., Mexico
Tandy, Edward H. El Segundo, Calif.
Tator, Kenneth Coraopolis, Pa.
Tatum, Joe F. Hattiesburg, Miss.
Tatum, John M. Hattiesburg, Miss.
Taylor, R. D. New York, N. Y.
Taylor, R. Derrill. Salt Lake City, Utah
Taylor, Walter E. Houston, Tex.
Teahan, James T. Staten Island, N. Y.
Teale, Edward P. Washington, D. C.
Teeple, H. O. New York, N. Y.
Teh, Chin What Columbus, Ohio
Temmerman, John A. Rochester, N. Y.
Terrill, J. Mark Chicago, Ill.
Terry, LeGrand E. Flushing, N. Y.
Texter, H. G. Tulsa, Okla.
Thalmann, E. H. Dallas, Tex.
Thatcher, Fred G. Las Piedras Falcon, Venezuela, S. A.
Thayer, Olin E. Houston, Tex.
Thayer, Starr Houston, Tex.
Thiede, Richard Conrad Grasselli, N. J.
Thistle, James F. Ashland, Ky.
Thomas, Arba H. Middletown, Ohio
Thomas, Beaumont Watertown, N. Y.
Thomas, J. F. J. Ottawa, Ontario, Canada
Thomas, Paul D., New York, N. Y.
Thomas, Ralph W. Waukesha, Wis.
Thompson, Charles H. Baldwin, N. Y.
Thompson, D. B., New York, N. Y.
Thompson, Harris Chicago, Ill.
Thompson, James B. Houston, Tex.
Thompson, John G. Washington, D. C.
Thompson, R. W. Big Spring, Tex.
Thompson, Roy T. Tulsa, Okla.
Thompson, Van Dallas, Tex.
Thomson, J. B. Big Rapids, Mich.
Thornberg, Joseph E. Niagara Falls, N. Y.
Thorne, Anthony Z. Bayonne, N. J.
Thorney, Charles E., Jr. Houston, Tex.
Thornhill, W. H. T. Westfield, N. J.
Thornton, J. A., Jr. Cleveland, Ohio
Thorpe, Vincent A. Freeport, Tex.
Thurrell, Roger F. Cincinnati, Ohio
Tibbetts, E. F. New York, N. Y.
Tice, E. Allen New York, N. Y.
Tietze, I. B. Bartlesville, Okla.
Timberlake, Philip S. Birmingham, Ala.
Tinney, Thomas B. Philadelphia, Pa.
Tisdale, C. R. Houston, Tex.
Titsworth, Edwin J., Boston, Mass.
Titterington, Y. W. Tulsa, Okla.
Todd, Raymond W., Jr. Chicago, Ill.
Todhunter, Harold A. South Pasadena, Calif.
Tohline, Max B. Beaumont, Tex.
Tomb, H. H. Lake Charles, La.
Tompkins, Albert H., Jr. Los Angeles, Calif.
Tour, Sam New York, N. Y.
Towne, Robert I. Caracas, Venezuela
Tracey, Edward J. J., Jr. State College, Pa.
Tracy, Arthur W. Waterbury, Conn.
Treichler, H. E. Newgulf, Tex.
Treseder, Richard S. Emeryville, Calif.
Trilsch, John D. Houston, Tex.
Tripler, Arch B., Jr. Columbus, Ohio
Trishman, L. E., Ambridge, Pa.
Trissal, J. M. Chicago, Ill.
Troseth, Ralph Midland, Tex.
Trouard, Sidney E. New Orleans, La.
Troupe, Ralph A. Akron, Ohio
Trout, H. E., Jr. Pittsburgh, Pa.
Trueblood, Howard M. Dobbs Ferry, N. Y.
Tuggle, Layton C. Houston, Tex.
Tuggle, Ray Houston, Tex.
Turbeville, Louis R. Dallas, Tex.
Turner, C. D. Philadelphia, Pa.
Turner, Delber W. Houston, Tex.
Turner, Elmer A. Malden, Mass.
Turner, Guy C. Houston, Tex.
Tuthill, Arthur H. Wilmington, Del.
Tyler, John C., Jr. South Houston, Tex.

U

Ubben, James E. Garland, Tex.
Uher, Joseph F. Cleveland, Ohio
Uhlig, H. H. Cambridge, Mass.
Uhr, Robert J. New Braunfels, Tex.
Ullrich, A. H. Austin, Tex.
Underwood, C. F. Aliquippa, Pa.
Underwood, O. G. Dayton, Ohio
Unruh, Earl W. Independence, Kan.
Updegraff, Norman C. Louisville, Ky.
Upton, Frederick P. Washington, D. C.
Urbanek, Joseph P. Philadelphia, Pa.
Urian, James H., Marcus Hook, Pa.

V

Vandaveer, F. E. Cleveland, Ohio
Van Delinder, L. S. South Charleston, W. Va.
Van Der Baan, S. Las Piedras, Estado Falcon Venezuela
Van der Haas, Hans Maatschappy, c/o C.O.I.M., Curacao, N.W.I.
Vander Hoeven, H. The Hague, Holland
Van Der Horst, Hendrik Olean, N. Y.
Vanderpool, Howard Philadelphia, Pa.
Vander Valk, Christy J. New York, N. Y.
Van De Water, Donald F. Philadelphia, Pa.
Van Etten, Frank M. Washington, D. C.
Vangsnes, K. T. Pasadena, Calif.
Van Horne, Roger H. Niagara Falls, N. Y.
Van Houten, Leslie P. New York, N. Y.
Vanick, James S., New York, N. Y
Van Loo, Maurice Chicago, Ill.
Van Natta, C. A. Chicago, Ill.
Van Nouhuys, Herbert C. Atlanta, Ga.
Van Oosterwijk, A. R. Kolff Amsterdam, Holland
Van Petton, Oliver W. Charleston, W. Va.
Van Rysselberge, Maurice Brussels, Belgium
Van Rysselberghe, Pierre Milano (132), Italy
Van Rysselberghe, Pierre Eugene, Ore.

Van Valkenburg, Jack.....Oklahoma City, Okla.
Van Vliet, R...Staten Island, N. Y.
Vaughan, Charles E.....West Monroe, La.
Vaughan, Lewis H...Alliance, Ohio
Vaughan, Wm. H.....Houston, Tex.
Vaurio, V. W.....Pittsburgh, Pa.
Veech, William A.....Caracas, Venezuela, S. A.
Vereeke, Edwin Wm.....Cleveland, Ohio
Verink, Ellis D., Jr.....New Kensington, Pa.
Vidovic, Paul P...Baton Rouge, La.
Viele, S. M.....Swarthmore, Pa.
Vierling, Wm.....Texas City, Tex.
Vines, E. D.....Woodward, Ala.
Vogel, Alfred J.....Andrews, Tex.
Volk, Kenneth Q.....Los Angeles, Calif.
Volkening, V. B.....Freeport, Tex.
Vollmer, Leslie W..Pittsburgh, Pa.
Vondrasek, H. W., Brentwood, Mo.
Von Lossberg, Lewis G.....Baltimore, Md.

W

Waber, James Thomas.....Los Alamos, N. M.
Wachter, Aaron...Emeryville, Calif.
Wade, O. W.....Houston, Tex.
Wade, Paul A.....El Campo, Tex.
Wafer, George W...Shreveport, La.
Wagner, Carl.....Cambridge, Mass.
Wagner, Ernest F.....Burlington, N. J.
Wagner, Frank W.....Lorain, Ohio
Wahlquist, Hugo W.....New York, N. Y.
Wahlquist, K. D.....Dallas, Tex.
Wainman, L. G.....El Paso, Tex.
Wainwright, Ray M....Urbana, Ill.
Walczak, M. R....New York, N. Y.
Waldie, Donald J.....Los Angeles, Calif.
Waldrip, H. E.....Houston, Tex.
Waldron, Leo J....Kensington, Md.
Walker, Basil G.....Minneapolis, Minn.
Walker, Henry S.....Detroit, Mich.
Walker, Hiram....Lockport, N. Y.
Walker, Jack R.....Shreveport, La.
Walker, James D.....Marion, Ohio
Wallace, E. W.....Bellaire, Tex.
Wallace, Robert P.....Williamsburg, Va.
Wallace, William P.....Oklahoma City, Okla.
Wallnau, Carl N., Jr.....New York, N. Y.
Walsh, Martin P.....St. Louis, Mo.
Walters, William A..Cleveland, Ohio
Walton, Charles J.....New Kensington, Pa.
Wamsley, Paul, Jr.....Baton Rouge, La.
Ward, Charles F.....Corpus Christi, Tex.
Ward, Thomas W.....South Gate, Calif.
Wardrop, William R..Buffalo, N. Y.
Waring, W. H.....Houston, Tex.
Warner, Clarence J....Decatur, Ill.
Warner, Eugene C.....Barberton, Ohio
Wasco, Joseph.....Midland, Mich.
Waterbury, C. L.....Chicago, Ill.
Waterman, Howard E.....Boise, Idaho
Waters, F. O....Los Angeles, Calif.
Watkins, Donald C.....Bartlesville, Okla.
Watkins, Franklin M...Harvey, Ill.
Watkins, Jesse L.....Iraan, Tex.
Watson, Amasa H..Fort Smith, Ark.
Watson, M. P....New Orleans, La.
Watson, Roger D.....El Paso, Tex.
Watson, T. R. B.....Toronto, Ontario, Canada
Watts, Admiral A...Columbus, Ohio
Watts, Bruce B.....Lincoln, Neb.
Watts, John C., Jr...Houston, Tex.
Weart, James G.....Springfield, Ill.
Weast, Robert C....Cleveland, Ohio
Weaver, James E.....Houston, Tex.
Weber, Martin K.....Emeryville, Calif.
Weber, Paul P.....Marshall, Tex.
Weede, J. D.....Atlanta, Ga.
Wegner, Harold C.....San Francisco, Calif.
Weidler, W. E., Jr...Houston, Tex.
Weinland, B. W.....Centralia, Ill.
Weise, F. F.....Wood River, Ill.
Weisert, Robert H.....Chicago, Ill.
Weiss, George H., Philadelphia, Pa.
Welch, Frank R.....Dayton, Ohio
Wells, C. Kenyon..Long Beach, Calif.
Welsh, Myron E.....Houston, Tex.
Werner, Daniel R.....Chicago, Ill.
Werner, Sanford F.....Webster Groves, Mo.
Wertz, Cyril J.....Cleveland, Ohio
Wescott, Blaine B., Pittsburgh, Pa.
West, Charles Howard.....Elizabeth, N. J.
West, John B.....Atlanta, Ga.
West, John F., Jr.....Allentown, Pa.
West, Lewis H.....Norwood, Pa.
Westcott, Ralph M.....Hollywood, Calif.
Westerhof, Elmer E..Jackson, Mich.
Wheatlake, B. K.....Denver, Colo.
Wheeler, A. W.....Shreveport, La.
Wheeler, Lionel Harris.....Houston, Tex.
Wheeler, Roger M.....Tulsa, Okla.
Whelen, J. T.....Neenah, Wis.
Whidden, Ira.....Miami, Fla.
Whitaker, H. E...New York, N. Y.
White, Robert L.....Degolia, Pa.
White, Robert P.....Harvey, La.
White, W. C.....Atlanta, Ga.
White, W. J.....Kirkwood, Mo.
White, Wm. K., Jr.....Providence, R. I.
Whiteneck, L. L.....Long Beach, Calif.
Whiting, L. R....New York, N. Y.
Whitley, B. J., Jr....Houston, Tex.
Whitmore, Clifton W...Miami, Fla.
Whitney, F. L., Jr...St. Louis, Mo.
Whitney, G. W...Los Angeles, Calif.
Whittier, Frederick..Hoboken, N. J.
Wicen, R. E.....Milwaukee, Wis.
Wickens, T. L.....Houston, Tex.
Widmer, Charles Max.....Cedar Rapids, Iowa
Wiegele, T. W.....Detroit, Mich.
Wiegers, Conrad L.....Charleston, W. Va.
Wieland, Warren E....Chicago, Ill.
Wilbanks, Hugh, Jr.....Corpus Christi, Tex.
Wilde, H. D.....Houston, Tex.
Wiles, Verland K...Cleveland, Ohio
Wiley, Lloyd R., Jr.....Dallas, Tex.
Wilgus, H. M.....New York, N. Y.
Wilkes, Frank M....Shreveport, La.
Wilkes, John F.....Chicago, Ill.
Wilkins, Archie M.....Eagle Lake, Tex.
Wilkinson, A. C.....Ponca City, Okla.
Williams, Chas. W...Louisville, Ky.
Williams, Dale E.....Youngstown, Ohio
Williams, Frank L.....New York, N. Y.
Williams, Geo. T...Davenport, Iowa
Williams, Guy F.....Tulsa, Okla.
Williams, Leonard W.....Coatesville, Pa.
Williams, Luther F.....San Francisco, Calif.
Williams, Robert D.....New Kensington, Pa.
Williams, Sanders A..Baltimore, Md.
Williams, Thomas P.....Philadelphia, Pa.
Williamson, Merritt A.....Hammond, Ind.
Williamson, T. D., Jr...Tulsa, Okla.
Williamson, Theodore...Dallas, Tex.
Willson, B. F.....Edmonton, Alberta, Canada
Wilmoth, E. G.....Enid, Okla.
Wilson, Bert.....Irving, Tex.
Wilson, D. W.....Cleveland, Ohio
Wilson, Fred V.....Beaumont, Tex.
Wilson, J. B.....St. Louis, Mo.
Wilson, John R....McKeesport, Pa.
Wilson, L. Alexander.....Marcus Hook, Pa.
Wilson, Norman D....Ankeny, Iowa
Wilson, P. S....Glen Ridge, N. J.
Wilson, Robert C.....Akron, Ohio
Wilson, Sam.....Tulsa, Okla.
Wilson, T. A....Farmington, N. M.
Wilten, Harry M.....Port Arthur, Tex.
Winchester, Charles T..Akron, Ohio
Winegartner, Edgar C.....Luckey, Ohio
Wimer, Charlton J.....Dallas, Tex.
Winham, E. S.....Houston, Tex.
Winters, B. W.....Atlanta, Ga.
Wirene, W. A...Schenectady, N. Y.
Wischhusen, John..Cleveland, Ohio
Wisdom, James A.....Van, Tex.
Wise, Robert S.....Chicago, Ill.
Withers, Frank P.....Chicago, Ill.
Wogan, Philip B....Westwego, La.
Wolf, Edgar F.....Baltimore, Md.
Wollaston, F. O.....Vancouver, B. C., Canada
Wood, C. Lee.....Houston, Tex.
Wood, Elgean I.....Houston, Tex.
Wood, F. M.....Houston, Tex.
Wood, F. T., Jr.....Santa Monica, Calif.
Wood, Hershel J.....Houston, Tex.
Wood, William A., Jr.....Houston, Tex.
Woodard, A. S.... Philadelphia, Pa.
Woodard, Wm. N....Trenton, N. J.
Woodland, Forrest, Jr.....Pittsburgh, Pa.
Woodman, Frank W.....Lake Charles, La.
Woodruff, Warren E.....Arcadia, Calif.
Woods, Eldro M.....Los Angeles, Calif.
Woodward, Henry F., Jr.....Pittsburg, Kan.
Woody, Charles L....Houston, Tex.
Woofter, Robert A...Pittsburgh, Pa.
Wooldridge, Kent E.....Milwaukee, Wis.
Works, George A., Jr.....Oleum, Calif.
Worth, John S.....Bethlehem, Pa.
Wray, T. Cecil....Nashville, Tenn.
Wright, Armour D., Jr.....Cleveland, Ohio
Wright, Edward C.....Long Beach, Calif.
Wright, Emerson H.....Murrysville, Pa.
Wright, Gordon R.....San Diego, Calif.
Wright, Howard P...Baltimore, Md.
Wright, Lewis S.....Ashland, Ky.
Wright, Nathan E., Beaumont, Tex.
Wright, Randolph Earle.....Houston, Tex.
Wyche, Ernest H....Coatesville, Pa.
Wyman, John D..Lake Charles, La.

Y

Yahnker, W. F.....Hicksville, L. I., N. Y.
Yates, Louie N.....Taft, Tex.
Yeatman, C. A...Los Angeles, Calif.
Yeazel, F. C....Franklin Park, Ill.
Yeldell, J. W.....Birmingham, Ala.
Yelton, Paul H.....Riverside, Calif.
Yorath, D. K.....Edmonton, Alberta, Canada
Young, Frank A., Philadelphia, Pa.
Young, George H., Pittsburgh, Pa.
Young, James W.....Calgary, Alberta, Canada
Young, Robert J., Ridgewood, N. J.
Younger, A. M..San Francisco, Calif

Z

Zajac, Ted S.....Houston, Tex.
Zange, Max.....Granite City, Ill.
Zapffe, Carl A.....Baltimore, Md.
Zaruba, Richard S....Houston, Tex.
Zastrow, Orville W.....Washington, D. C.
Zauner, John Hudson.....Cabimas, Estado Zulia, Venezuela, S. A.
Zedler, Otto F.....Houston, Tex.
Zelders, Diplom Ing, Herman G....Geleen, Holland
Ziebold, H. O.....St. Louis, Mo.
Zima, Albert G., Los Angeles, Calif.
Zimmerer, Robert I.....South Charleston, W. Va.
Zinser, A. L.....Austin, Tex.
Zipper, Donald H.....Chicago, Ill.
Zorko, Frank A.....Cleveland, Ohio
Zvarick, Albert J., Norristown, Pa.

Geographical Listing of Members

The names followed by an asterisk (*) are those of Junior Members

"Representatives" of Corporate Members are included in this Geographical Listing of Members. To determine if a member is a representative of a Corporate Member refer to the alphabetical list of Corporate Members on pages 30 to 33.

ALABAMA

ANNISTON

CHADWICK, David H., Research Dept. Phosphate Div., Monsanto Chemical Co.

BESSEMER

MEGLEMRE, Robert W.*, Hercules Powder Co., Box 190

BIRMINGHAM

BLANKENSHIP, Fred R., Jr., Southern Natural Gas Co., Box 2563.
BRAMLETTE, Robert C., American Cast Iron Pipe Co., Box 2603.
DAVIS, R. A., Chicago Bridge & Iron Co., 1500 N. 50th St.
DENT, Herbert W., Jr., American Cast Iron Pipe Co., Box 2603.
DONOHO, Charles K., American Cast Iron Pipe Co., Box 2603.
DONOVAN, W. H., Jr., Alabama Gas Corp., Watts Bldg.
GAMBLE, Chas. B., Jr., Alabama Gas Corp., Watts Bldg.
GARRETT, William W., Tennessee Coal, Iron & Railroad Co., Fairfield, Ala. For mail: 1401 Bush Blvd.
GRIFFIN, Everett M., Southern Bell Telegraph & Telephone Co., Phoenix Bldg.
MACKENZIE, James T., American Cast Iron Pipe Co., Box 2603.
McCAULEY, E. D., American Cast Iron Pipe Co., 2030 N. 16th St.
MILAS, Alfred B., Birmingham Water Works Co., 2114 1st Ave., N.
REED, Ramsey M., United States Pipe & Foundry Co., First National Bldg.
TIMBERLAKE, P. S., Birmingham Electric Co., 2100 First Ave. North.
YELDELL, J .W., General Supt., Southern Natural Gas Co., Box 2563.

CAMP RUCKER

BAMMEL, Charles A., M-Sgt., 38756139 H & S Company, 432nd Engr. Constr. Bn. *

DECATUR

HONKALA, H. E., Wolverine Tube Div., Calumet & Hecla Consol. Copper Co.

FAIRFIELD

HILL, J. Ernest, 4917 Farrell Ave.

FLORENCE

BARTMESS, Lewis C., Alabama-Tennessee Natural Gas Co.

HUNTSVILLE

HAGER, Karl F., Redstone Arsenal, Huntsville, Ala. For mail: 707 College Hill.

MOBILE

STRANGE, Harold T., Mobile Gas Service Corp., Box 1130.

TARRANT

ADAMS, Jack W., Southern Natural Gas Co., Box 6327.

WOODWARD

VINES, E. D., Koppers Co., Inc., Tar Products Div.

ARIZONA

COOLIDGE

BELL, Lawrence H., Natural Gas Service Co. of Arizona, Box 127.

PHOENIX

CHAPMAN, Walter H., El Paso Natural Gas Co., Phoenix, Ariz. For mail: 6015 S. Seventh Ave.
JACKSON, Russell, Rust-Proofing, Inc., 1220 E. Henshaw Rd.

ARKANSAS

EL DORADO

BERTETTI, J. W., Pan Am Southern Corp., Box 791.
HOIBERG, Arnold J., Lion Oil Co.
ROGERSON, J. B., Lion Oil Co.

FAYETTEVILLE

HALSELL, Hampton L., Arkansas Western Gas Co.

FORT SMITH

MURRAY, Capt. Herman, 3107 North "L" St.
WATSON, Amasa H., Jr., Arkansas-Oklahoma Gas Co., 35 South 7th.

HOT SPRINGS NATIONAL PARK

HUDACHEK, Raymond J., 1704 W. Grand Ave.

LITTLE ROCK

GREEN, W. A., Midsouth Gas Co., 215 Commerce St.

NEWPORT

SHEETS, Earl T., Oklahoma Glass Fiber Corp., Box 281.

CALIFORNIA

ALHAMBRA

ENQUIST, Melvin A., Deady Chemical Co., Los Angeles, Calif. For mail: 1609 Azalea Drive.
NASH, William F., Jr., C. F. Braun & Co., 1000 S. Fremont St.

ALTADENA

HALSTED, Hal F., Reed Halsted & Co., 2020 North Lake.

ARCADIA

SKAFTE, Stanley F., Utility Appliance Corp., 5429 N. Cochin Ave.
WOODRUFF, Warren E., Technical Service Co., 400 Fairview Ave.

ASSOCIATED

STORM, Arthur E., Tide Water Assoc. Oil Co.

AVENAL

KNOWLTON, Drexel R., Kettleman North Dome Association, Bin C.

AZUSA

STROMSOE, Douglas A., Southern Pipe & Casing Co., Box C.

BAKERSFIELD

SMITH, Clair J., Western Gulf Oil Co., Box 471.

BALDWIN PARK

NELSON, H. Lloyd, United Concrete Pipe Corp., Box 425.

BELL

SCHILLING, W. M., Southern Counties Gas Co., 4818 Beck Ave.

BERKELEY

FREEMAN, C. E., C. E. Freeman Co., Inc., 1101 Second St.
JURS, Peter C., Shand & Jurs Co., 917 Carlton St.

BEVERLY HILLS

O'LEARY, Frederick James, The Barrett Div., Allied Chemical & Dye Corp., Los Angeles, Calif. For mail: 308 S. Clark Drive.
PENDERGAST, Hugh W., 158 N. Arnaz Dr.
SMALL, Richard B., California Research and Development Co., San Francisco, Cal. For mail: c/o S. C. Vance, 427 Beverwil Dr.

COMPTON

LONG, Frank V., Sr., Vapor Recovery Systems Co., Box 231.

EL CERRITO

BREITENBACH, Paul, Pacific Gas & Electric Co., Emeryville, Calif. For mail: 708 Avila Place.

EL SEGUNDO

KEYT, Ernest B., California Research Corp., El Segundo Laboratory, 324 W. El Segundo Blvd.
MARADUDIN, Alexei P., Standard Oil Company of California.
TANDY, Edward H., Standard Oil Company of California, Box 97.

EMERYVILLE

BRADY, Merritt H., Electrolysis Dept., Pacific Gas & Electric Co., 4245 Hollis St.
DEAN, Roy O., Pacific Gas & Electric Co., 4245 Hollis St.
ELDREDGE, George G., Shell Development Co.
MILLER, Ross F., Shell Development Co., 4560 Horton St.
RAIFSNIDER, Philip J., Shell Development Co., 4560 Horton.
SCHNEIDER, Wm. R., Pacific Gas & Electric Co., 4245 Hollis St.
TRESEDER, Richard S., Shell Development Co., 4560 Horton St.
WACHTER, Aaron Attn: Librarian, Shell Development Co., 4560 Horton St.
WEBER, Martin K., Shell Development Co., 8560 Horton St.

FONTANA

AUBREY, Richard, Kaiser Steel Corp., Box 217.
MADDEN, R. C., Kaiser Co., Inc., Iron & Steel Div., 202 S. Palmetto.

GLENDALE

ENGELHARDT, Robert Lee, General Controls Co., 801 Allen Ave.

HOLLYWOOD

WESTCOTT, Ralph M., 1443 N. Alta Vista Blvd.

HUNTINGTON PARK

McARTHUR, Ralph F., Kobe, Inc., 3040 E. Slauson Ave.
STOKES, William S., National Pipe Coatings, Inc., 3480 E. Randolph St.

INGLEWOOD

BROWN, John R., Kobe, Inc., Huntington Park, Cal. For mail: 3525 West 74th Place.

LA HABRA

McCLOUD, Dwite M., California Research Corp., Box 446.

LA MESA

FLOR, Loy L., La Mesa, Lemon Grove & Spring Valley Irrigation District, 4769 Spring St.
SHELTON, M. J., La Mesa, Lemon Grove & Spring Valley Irrigation District, 4769 Spring Street.

LA VERNE

STREICHER, Lee, Metropolitan Water District of Southern California, Box 38.

LINCOLN

JOHNSON, Elmer A., Johnson & McIntosh, Consulting Engineers, 571 G St., Lincoln Theater Bldg.

LONG BEACH

DUNHAM, R. A., 2930 E. Fifth St.
ENDERS, Roger S., The Hancock Oil Co. of California, Box 810.
GRAY, R. M., Long Beach Oil Development Co., 255 S. Santa Clara Ave.
HUBER, Karl E., Oilwell Research, Inc., 330 Pomona Ave.

MARKHAM, Wendell G., International Cementers, Inc., 6505 Paramount Blvd.
NOSS, Oscar F., Jr., 1222 East 1st St.
WELLS, C. Kenyon, Long Beach Water Dept., 215 W. Broadway.
WHITENECK, L. L., Long Beach Harbor Dept., 1333 El Embarcadero.
WRIGHT, Edward C., City of Long Beach Municipal Gas Dept., 215 W. Broadway.

LOS ANGELES

APERULE, Charles J., Jr., Warren & Bailey Co., 350 S. Anderson St.
ASHLINE, Robert R., 410 Ducommun St.
BARCUS, E. Dale, Pacific Telephone and Telegraph Co., 740 S. Olive St.
BARNARD, W. E., Barnard Chemical Co., 4557 E. Slauson.
BEENFELDT, Earl L., National Lead Co., 3113 E. 26th St.
BLACK, Bobby E., Southern Cal. Gas Co., Box 3249, Terminal Annex.
BLAKE, J. A., Electric Steel Foundry Co., 4600 Pacific Blvd.
BLECKSMITH, C. C., Duncan Electric Manufacturing Co., 164 S. Central Ave.
BLOHM, Clyde L., The Fluor Corp., Ltd., 2500 S. Atlantic Blvd.
BOWEN, James V., General Petroleum Corp., Box 2122, Terminal Annex.
BRADFIELD, Stephen A., Southern California Gas Co., 810 S. Flower St.
BRADLEY, F. E., Chanslor-Canfield Midway Oil Co., 4549 Produce Plaza West.
BRIGGS, H. L., Chanslor-Canfield Midway Oil Co., 4549 Produce Plaza West.
CATES, Walter H., Consolidated Western Steel Corp., Box 2015, Terminal Annex.
CLARKE, B. C., Pacific Metals Co., Ltd., 1400 S. Alameda St.
CORFIELD, Guy, Southern California Gas Co., Box 3249, Terminal Annex.
DICKINSON, W. F., Consolidated Western Steel Corp., Box 2015 Terminal Annex.
DIETZE, Irwin C., Dept. of Water and Power, City of Los Angeles, Box 3669, Terminal Annex.
DOD, A. Bayard, Jr., Phelps Dodge Copper Products Corp., 6100 Garfield Ave.
DORSEY, Joseph S., Southern California Gas Co., Box 3249, Terminal Annex.
DOUGLASS, Harry E., Stewart R. Browne Manufacturing Co., Inc., 1065 Riverside Drive.
DUIM, Albert R., Mission Appliance Corp., Hyde Park Station.
ELLIOTT, Jack H., Los Angeles County Air Pollution Control, Los Angeles, Cal. For mail: 11062 S. Ruthelen Ave.
EUBANKS, Erdie B., Jr., Amerada Petroleum Corp., 417 S. Hill St.
GALLAGHER, John S., The Texas Co., Los Angeles, Cal. For mail: 1037 Burnside Ave.
GILBERT, T. H., Southern California Gas Co., Box 3249, Terminal Annex.
GOIT, Laurance E., Dept. Water & Power of Los Angeles, 207 S. Broadway.
GREBSTAD, Ernest H., Southern California Gas Co., 1700 S. Santa Fe.
GREEN, Willis G., General Petroleum Corp., 2721 East 37th St.
GRIZZARD, Eugene H., Signal Oil & Gas Co., 811 W. Seventh St.
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GRAYVILLE

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KLUMB, George H., Culligan Zeolite Co.

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CLINTON

PELTON, Charles H., Clinton Foods, Inc.

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PADUCAH

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NORTH BATON ROUGE

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JACKSON, C. M., Devoe & Raynolds Co., Rutherford & Delancey Sts.
LACHMUND, D. O., Amercoat Corp., 29 New York Ave.
LEFEBVRE, Fabian J., Electro Rust-Proofing Corp., Box 178.
MEANY, John J., Jr., Transcontinental Gas Pipeline, Inc., Industrial Bldg.
SALMON, Philip A., Public Service Electric & Gas Co., 80 Park Place.
SCHIFF, Melvin J., Electro Rust-Proofing Corp., Box 178.
STROM, C. F., American Steel Foundries, Avenue L & Herbert St.
SUDRABIN, Leon P., Electro Rust-Proofing Corp., Box 178.

NEW BRUNSWICK

McWHORTER, Sam B., General Coating Co., New Jersey. For mail: 7 Poe Ave.

NORTH PLAINFIELD

RICHARD, Charles S., 268 Manning Ave.

NUTLEY

COHEN ,Ralph, Hoffman La Roche, Inc., Roche Park.

PASSAIC

EVEREST, Guy N., Okonite Co.

PATERSON

BENNETT, Charles E., The Okonite Callender Cable Co., Inc., 730 21st Ave.
GARRISON, V. L., Okonite Callender Cable Co., Inc., 730 21st Ave.

PAULSBORO

BENNETT, H. Howard, Socony-Vacuum Oil Co., Inc.

PENNS GROVE

DEGNAN, Thomas F., E. I. duPont De Nemours & Co., Chambers Works.

PERTH AMBOY

PETTEE, Allen D., General Cable Corp., 26 Washington St.

PHILLIPSBURG

CANN, Kenneth R., Ingersoll-Rand Co.

PITMAN
GLIDDEN, William E., 120 Morris Ave.

PLAINFIELD
HERSTEIN, F. E., General Ceramics & Steatite Corp., Keasbey, N. J. For mail: 812 Carlton Ave.
KLEINHEKSEL, S., Socony-Vacuum Oil Co., Inc., Eastern P. L. Div., Box 266.
STUART, Linden, Jr., The Barrett Div., Allied Chemical & Dye Corp., New York, N. Y. For mail: 970 Hillside Ave.

RAHWAY
SUTHERLIN, James E., Merck & Co., Inc.

RIDGEFIELD
MATHERS, W. D., Aluminum Company of America, New York, N. Y. For mail: 643A Bruce St.

RIDGEWOOD
CARR, Joseph A., Village of Ridgewood, 38 Oak St.
YOUNG, Robert J., Hill Hubbell & Co., Div. of General Paint Corp., 642 Spring Ave.

RIVERSIDE
FREYNIK, Henry S., The Riverside Metal Co.

ROSELLE
DOSS, Glenn K., Standard Oil Development Co., 768 E. Second Ave.

SOUTH AMBOY
LEE, R. P., Nat'l. Lead Co-Titanium Div., Box 58.

TRENTON
JORCZAK, Joseph S., Thiokol Corp., 780 North Clinton Ave.
SUVERKROP, E. A., John A. Roebling's Sons Co., 640 S. Broad St.
WOODWARD, Wm. N., De Laval Steam Turbine Company.

UNION
DOUGHTY, S. E., The Carpenter Steel Co., Alloy Tube Div., Springfield Rd.
MORRISON, Barclay, The Carpenter Steel Co., Springfield Rd.
STAPLES, Wm. R., Carpenter Steel Co.

WEEHAWKEN
ALFKE, C. J., Hackensack Water Co., 4100 Park Ave.

W. ENGLEWOOD
MILLER, M. C., Ebasco Services, Inc., New York, N. Y. For mail: 1142 Emerson Ave.

WESTFIELD
FAIR, W. F., Jr., Koppers Co., Inc., Tar Products Div., Box 390, 449 South Ave.
PITTMAN, Charles U., Koppers Co.
THORNHILL, W. H. T., Tar Products Division, Koppers Co., Inc., Box 390.

WEST ORANGE
MEAD, William J., Colgate-Palmolive-Peet Co. For mail: 113 Longview St., Hutton Park.

WOODBURY
FASIG, Paul L., Socony-Vacuum Oil Co., Inc., Paulsboro, N. J., For mail: 173 Leeds Place.

NEW MEXICO

ALBUQUERQUE
RUSSELL, John C., Sandia Corp., Albuquerque, N. M. For mail: 3272 47th St., Sandia Base.

CARLSBAD
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SMITH, Randal E., Potash Company of America, Box 31.

FARMINGTON
WILSON, T. A., Southern Union Gas Co., Box 337.

LOS ALAMOS
WABER, James Thomas, Los Alamos Scientific Laboratories, Box 1663.

NEW YORK

ARDSLEY
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BALDWIN
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THOMPSON, Charles H., 56 E. Stanton Ave.

BAYSIDE
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BRONX
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BROOKLYN
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BLACKBURN, Douglas B., The Debevoise Co., 74-84 20th St.
BROWN, Gordon W., Cheesman Elliot Co., 639 Kent Ave.
CAMERON, William B., Brooklyn Union Gas Co., 176 Remsen St.
CHRIST, George J., New York Telephone Co., 101 Willoughby.
CIBORSKI, John M., National Lead Co. Res. Lab., 105 York St.
DEBEVOISE, George D., The Debevoise Co., 74-84 20th St.
DIEHLMAN, George, Research Laboratories, National Lead Co., 105 York St.
DREYMAN, Edgar W., Kirkaldy System, Inc., 425 Hamilton Ave.
EICKHOFF, Arnold J., National Lead Co., Research Laboratories, 105 York St.
HALE, William L., The Debevoise Co., 968 Grand St.
HAWKE, David L., National Lead Co., Research Labs., 105 York St.
HIERS, George O., National Lead Co., Research Lab., 105 York St.
MOORE, Roy W., Socony-Vacuum Oil Company Labs., 412 Greenpoint Ave.

BUFFALO
BIONDOLILLO, Sando, Bell Aircraft Corp., 411 Baynes.
CHANDLER, John W., Nukem Products Corp., 111 Colgate Ave.
DuBOIS, Carlton H., Socony-Vacuum Oil Co., Inc., 503 Elk St.
DUNN, E. F., 254 Court St.
GUENTHER, Paul R., Nukem Products Co., 111 Colgate Ave.
KAUFMANN, D. W., International Salt Co., Inc., Marine Trust Bldg.
MALONEY, Eugene E., John J. Gordon Co., 220 Broadway.
McELROY, Charles R., Metal-Cladding, Inc., 128 Lakeview Ave.
MERRILL, Harry E., Republic Light, Heat & Power Co., Inc., 220 Delaware Ave.
MORAN, Joseph H., 265 Hoyt St.
NICHOLSON, C. T., Niagara Mohawk Power Corp., Office Library, Electric Bldg.
ROBB, Edward H., Bisonite Co., Inc., 128 Lakeview Ave.
SMITH, Walter R., Nukem Products Corp., 111 Colgate Ave.
WARDROP, William R., Metal-Cladding, Inc., 128 Lakeview Ave.

CHAUNCEY
CECCON, J. B., Stauffer Chemical Co.

CORNING
KROCHMALSKI, Edward, Corning Glass Works.

DEPEW
BUEHLMANN, J. G., The Symington-Gould Corp., 2 Main St.

DOBBS FERRY
TRUEBLOOD, Howard M., 96 Bellair Drive.

FLUSHING
MOE, John L., Ebasco Services Inc., New York, N. Y. For mail: 144-35 Roosevelt Ave.
SHEPARD, Arthur P., 29-01 159th St.
TERRY, LeGrand E., Minnesota Mining & Manufacturing Co., Ridgefield, N. J. For mail: 35-21 149th St.

FREEPORT
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HICKSVILLE
YAHNKER, W. F., The Glasfloss Corp., New South Rd.

JAMACIA
MONTEL, Joseph I., Water Service Laboratories, Inc., New York, N. Y. For mail: 175-27 Wexford Terrace.

LOCKPORT
CLIFFORD, Hugh J., Harrison Radiator Div., G. M. C.
GODFREY, John W., General Motors Corp., Harrison Radiator Div.
LAWTON, Ledra M., Harrison Radiator Div., General Motors Corp., Washburn.
WALKER, Hiram, Harrison Radiator Div., General Motors Corp.

LONG ISLAND CITY
BOLTZ, David C., Metallizing Engineering Co., Inc., 38-14 30th St.
COLLINS, Harry S., Metallizing Engineering Co., Inc., 3814 30th St.
FRIEDMAN, Charles, Paragon Paint & Varnish Corp., 5-49 46 Ave.
GERBEN, Max, Gerben Contracting Co., Inc., 36-11 Ditmars Blvd.
GRAVES, Colburn R., Long Island Lighting Co., Stewart Ave., Garden City.
INGHAM, Herbert S., Metallizing Engineering Co., Inc., 38-14 30th St.
McWATERS, Raymond J., Metallizing Engineering Co., Inc., 38-14 30th St.
POWER, Pierce H., Paragon Paint & Varnish Corp., 5-49 46th Ave.
SMITH, Vernon R., Metallizing Engineering Co., Inc., 38-14 30th St.
STERNE, Cecil M., Metropolitan Refining Co., Inc., 50-23 Twenty-third St.

MINEOLA
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MT. VERNON
LATTIN, Benton Calver, Westchester Lighting Company, 9 S. First Ave.

NEW YORK
ALDINGER, Fred, California Texas Oil Co., 551 Fifth Ave.
ALTENBURG, Charles J., Gibbs & Cox, Inc., 21 West St.
ANDREW, Harold O., Moore-Publishing Co., Inc., 9 E. 38th St.
AYRES, Robert Finley, Oakite Products, Inc., 22 Thames St.
BAGNELL, William E., Ebasco Services, Inc., 2 Rector St.
BAILEY, Clark A., Johns-Manville Sales Corp., 22 E. 40th St.
BALDWIN, L. A., Johns-Manville Sales Corp., 22 E. 40th St.
BARRON, Donald W., Albert F. Ganz, Inc., 511 Fifth Ave.
BEBBINGTON, Marguerite, International Nickel Co., Inc., 67 Wall St.
BECK, Walter, 780 Riverside Dr., Apt. 2G.
BECKER, Wm. D., Burns & Roe, Inc., 233 Broadway.
BOYD, George E., Koppers Co., Inc., 350 Fifth Ave.
BREMER, Clarence, Oakite Products, Inc., 22 Thames St.
BRITTON, H. B., Trans-Arabian Pipe Line Co., 505 Park Ave.
BROWN, Charles J., The International Nickel Co., Inc., 67 Wall St.
BUENSOD, A. C., Buensod-Stacey, Inc., 60 East 42nd St.
COLE, Frank H., Walworth Co., 60 East 42nd Street.
COLLINS, Walter F., New York Central Railroad Co., 466 Lexington Ave.
COURT, W. F., Shell Oil Co., Inc., 50 W. 50th St.
COWART, B. C., Barrett Div., Allied Chemical & Dye Corp., 40 Rector St.
COYLE, T. G., United Chromium, Inc., 100 East 42nd St.
CROSBY, William L., Consolidated Edison Company of New York, Inc., 708 1st Ave.
DANSER, J. W., American Telephone & Telegraph Co., 195 Broadway.
DANTZ, Thomas M., The Ruberoid Co., 500 Fifth Ave.
DE LASKI, Robert D., W. A. Briggs Bitumen Co., 30 Church St.
DE MEY, C. F., Columbia Engineering Corp., 120 E. 41st St.
DEVOLUY, Raymond, C. A. Woolsey Paint & Color Co., Inc., 229 E. 42nd St.
DICKINSON, L. R., Socony-Vacuum Oil Co., Inc., 26 Broadway.
DONOVAN, Lewis B., Consolidated Edison Company of New York, Inc., 4 Irving Place.
EVANS, Clair O., Phelps Dodge Copper Products Corp., 40 Wall St., 43rd Floor.
EVERETT, Ralph H., M. J. Merkin Paint Co., Inc., 1441 Broadway.
EVES, W. D. Heath, Anglo-Iranian Oil Co., Ltd., 610 Fifth Ave.
FARKAS, Howard, The U. S. Stoneware Co., 60 E. 42nd St.
FOSTER, Albert C., Standard Brands, Inc., 595 Madison Ave.
FRIEND, W. Z., International Nickel Co., Inc., 67 Wall St.
FRIZ, Nelson, Esso Standard Oil Co., 15 W. 51st St.
GARDNER, Karl A., Griscom-Russell Co., 285 Madison Ave.
GERMAN, Alfred, Scovill Manufacturing Co., Chrysler Bldg.
GOLDSBY, Fred L., Chicago Bridge & Iron Co., 165 Broadway.
GORMAN, L. J., Consolidated Edison Company of New York, 4 Irving Place.
GOUDIELOCK, William B. O'Brien, Phelps-Dodge Copper Products Corp., 40 Wall St.
GREBINAR, Herbert L., Chase Chemical Corp., 40 West 29th St.
GRUBER, K. A., Chemical Fire and Rust Proofing Corp., 508 East 117th St.
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HAMLIN, Arthur W., Ebasco Services, Inc., 2 Rector St.
HELMBRECHT, A. J., The Buckeye Pipe Line Co., 30 Broad St.
HENDERSON, Walter A., New York Telephone Co., 140 West St.
HERSAM, G. Russell, Prufcoat Laboratories, Inc., 50 East 42nd St.

HOYT, W. B., The M. W. Kellogg Co., 225 Broadway.
HUNTLEY, Harold R., American Telephone & Telegraph Co., 195 Broadway.
JOECKS, Adolph K., Consolidated Edison Co. of New York, Inc., 708 First Ave.
JOHNSON, Carl R., The Port of New York Authority, 111 Eighth Ave.
JOHNSON, R. K., Darling Valve & Manufacturing Co., 70 Pine Street.
JOHNSTON, Howard E., Dearborn Chemical Co., 205 E. 42nd St.
JORDAN, Harry E., American Water Works Association, 500 Fifth Ave.
KAHN, Walter C., Jr., New York Testing Laboratories, 80 Washington.
KLEIN, Fred. M., Maurice A. Knight Co., 55 W. 42nd St.
KNOWLTON, A. E., Electrical World, 330 W. 42nd St.
KOESTER, H. F., Consolidated Edison Company of New York, Inc., 708 First Ave.
KRUEGER, Forrest J., National Aniline Div., Allied Chemical & Dye Corp., 40 Rector St.
KULMAN, Frank E., Consolidated Edison Company of New York, Inc., 4 Irving Place.
LAIN, George D., American Iron & Steel Institute, 350 Fifth Ave.
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LANG, Franklin, Feedwaters, Inc., 140 Cedar St.
LaQUE, F. L., International Nickel Co., Inc., 67 Wall St.
LEHMANN, Joseph A., Ebasco Services Inc., 2 Rector St.
LOPEZ, Eugene R., Barrett Division, Allied Chemical & Dye Corp., 40 Rector St.
MAITLAND, T. J., American Telephone & Telegraph Co., 32 Sixth Ave.
MARSHALL, Dwight, St. Joseph Lead Co., 250 Park Ave.
MASON, John F., Jr., International Nickel Co., Inc., 67 Wall St.
MAY, Thomas P., International Nickel Co., Inc., 67 Wall St.
MEIER, Alfred O., Shell Oil Co., 50 West 50th Street.
MEYER, Philip A., Gama Industries, Inc., 70 Pine St.
MORSE, Robert E., American Gas & Electric Service Corp., 30 Church St.
MORTON, Byron B., International Nickel Co., Inc., 67 Wall St.
MULLER, Herman, Jr., New York & Richmond Gas Co., 691 Bay St., Stapleton, S. I. 4.
NEHER, Frank H., The Flintkote Co., 30 Rockefeller Plaza.
NOLAN, Vincent J., National Carbon Division, Union Carbide & Carbon Corp., 30 E. 42nd Street.
NOPPEL, E. P., Ebasco Services, Inc., 2 Rector St.
O'KEEFE, John F., Reynolds Metals Co., 19 E. 47th St.
OTTOLENGHI, Mario L., 21 West St., Room 2606.
PERKINS, Wendell L., Ebasco Services, Inc., 2 Rector St.
PETERS, Fred P., Reinhold Publishing Corp., 330 W. 42nd St.
PIRSH, Edward A., Babcock & Wilcox Co., 85 Liberty.
PLACE, George W., American Bureau of Shipping, 45 Broad St.
PLOG, Charles B., Standard-Vacuum Oil Co., 42 Broadway.
PORSON, Allan B., Phelps Dodge Copper Products Corp., 40 Wall St.
PRIESTLEY, Henry L., Electro Metallurgical Div., Union Carbide & Carbon Corp., 30 East 42nd St.
PRINCE, Arthur E., Otis Elevator Co., 260 Eleventh Ave.
QUIMBY, W. S., The Texas Co., 135 E. 42nd St.
RIDDICK, Thomas M., Consulting Engineer & Chemist, 369 E. 149th St.
RIMBAULT, E. L., Jr., Federated Metals Div., American Smelting & Refg. Co., 120 Broadway.
ROBBINS, John T., Peter A. Frasse & Co., Inc., 17 Grand St.
ROBINSON, Vincent D., Dearborn Chemical Co., 205 E. 42nd St.
ROLL, Kempton H., Lead Industries Association, 420 Lexington Ave.
SAMPLE, Clarence H., International Nickel Co., Inc., 67 Wall St.
SANDS, George A., Union Carbide & Carbon Corp., 30 E. 42nd St.
SAUL, Edgar R., New York Telephone Co., 140 West St.
SCAROLA, V. J., Tapecoat Co., 489 Fifth Ave.
SCHOFER, Nathan, Hydrocarbon Res. Inc., 115 Broadway.
SHAW, A. G., Ebasco Services, Inc., 2 Recto.r Street.
SHEPARD, Spencer W., American Cyanamid Co., 30 Rockefeller Plaza.
SHOUMATOFF, Nicholas, West Virginia Pulp & Paper Co., 230 Park Ave.
SHULDENER, Henry L., Water Service Laboratories, 423 W. 126th St.
SKINNER, Edmond N., Jr., International Nickel Co., Inc., 67 Wall St.
SMITH, Sydney S., Shell Oil Co., 50 West 50th Street.
SNELL, Clark A., Nicholson & Galloway, Inc., 426-28 E. 110th St.
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THOMAS, Paul D., Asiatic Petroleum Co., Materials Dept., 50 W. 50th St.
THOMPSON, D. B., The New York Central Railroad Co., 466 Lexington Ave.
TIBBETTS, E. F., The Lummus Co., 385 Madison Ave.
TICE, E. Allen, International Nickel Co., 67 Wall St.
TOUR, Sam, Sam Tour & Co., Inc., 44 Trinity Place.
VANDER VALK, Christy J., Lead Industries Ass'n., 420 Lexington Ave.
VAN HOUTEN, Leslie P., American Telephone & Telegraph Co., 100 William St.
VANICK, James S., International Nickel Co., 67 Wall St.
WAHLQUIST, Hugo W., Ebasco Services, 2 Rector St.
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WALLNAU, Carl N., Jr., Standard Oil Company of New Jersey, 30 Rockefeller Plaza.
WHITAKER, H. E., Ford, Bacon & Davis, Inc., 39 Broadway.
WHITING, L. R., Bakelite Corp., 30 E. 42nd St.
WILGUS, H. M., Celanese Corp. of America, 2 Park Ave.
WILLIAMS, Frank L., Consolidated Edison Co. of N. Y., Inc., 708 1st Ave.

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NORTH TONAWANDA

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IDERSTINE, Robert Van, The Pfaudler Co., 1000 West Ave.
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MacCOLLUM, Donald R., Rochester Gas & Electric Corp., 89 East Ave.
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STATEN ISLAND

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SYRACUSE

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JAMES, Paul W., San-Equip, Inc., E. Brighton & Glen Ave.
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KELLOGG, Andrew, Niagara Mohawk Power Corp., 300 Erie Blvd., West.

UTICA

EARL, Robert, Jr., Earl Paint Corp., 240 Genesee St.

WATERTOWN

THOMAS, Beaumont, Stebbins Engineering and Manufacturing Co., Eastern Blvd.

WELLSVILLE

STARK, Conrad, Air Preheater Corp., 122 S. Main St.

NORTH CAROLINA

ASHEVILLE

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CHARLOTTE

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BURNETT, William C., Southern Bell Telephone & Telegraph Co., Box 240.
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KANNAPOLIS

SILLS, T. O., Cannon Mills Co.

TARBORO

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OHIO

AKRON

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NERHOOD, H. Elmer, 1193 Berwin St.
POWERS, Stanley C., U. S. Stoneware Co., Box 350.
SIDDALL, D. F., The U. S. Stoneware Co., Box 350.
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WILSON, Robert C., Ohio Edison Co., 47 N. Main St.
WINCHESTER, Charles T., Goodyear Tire & Rubber Co., 1144 E. Market.

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VAUGHAN, Lewis H., Babcock-Wilcox Res. & Dev., Harrisburg & Sawburg Rds.

BARBERTON

BRONSTEIN, Emanuel H., The Ric-Wil Co.
GEGNER, Paul J., Pittsburgh Plate Glass Co.,
WARNER, Eugene C., Akron Sand Blast Co., 50 E. Springfield Rr.

CANTON

CLARK, Claude L., Timken Roller Bearing Co., Steel & Tube Div.

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FRANEK, John A., 820 Ludlow Ave.*
GOETZ, Alvin C., Eagle-Picher Company, American Bldg.
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LEDERER, Lewis M., Inner-Tank Lining Corp., 1097 Wade St.
LINEBACK, George A., Cincinnati Gas & Electric Co., Fourth and Plum Sts.
LOCKEMAN, George F., The Procter & Gamble Co., Engineering Div., M. A. & R. Bldg., Ivorydale.
MALCOM, V. V., Special Industries Dept., The Philip Carey Mfg. Co., Lockland.
McDUFFIE, Roy O., University of Cincinnati.
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PAUL, Robert J., Emery Industries, Inc., June and Long Sts.
PFEIFFER, Milton J., The Cincinnati Gas & Electric Co., Box 960.
ROMELL, Robert F., The Vulcan Copper & Supply Co., 120 Sycamore St.
ROUTSON, L. B., Western Union Telegraph Co., Dixie Terminal Bldg., South.
SCHREINER, William J., Cincinnati Gas & Electric Co., 323 Plum St.
SHORT, Howard E., Cincinnati Milling Machine Company, Cimcool Div., 4701 Marburg Ave.
SWAY, Boris, The Texo Corp., Dana and Floral Sts.
THURRELL, Roger F., Aluminum Company of America, 801 Enquirer Bldg.

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BALL, Charles I., The Standard Oil Co., (Ohio), 2735 Broadway.
BANFIELD, George H., Wilson Metal Products Co., 19625 Lake Rd.
BELLER, Clarence J., The Cleveland Electric Illuminating Co., 75 Public Square.
BIXBY, Willard F., B. F. Goodrich Chemical Co., Rose Bldg.
BOWEN, Milton M., Hill-Hubbell Div., General Paint Corp., 3091 Mayfield Rd.
BREEZE, Lewis K., Glascote Products, Inc., 20900 St. Clair Ave.
BUNDY, Alfred D., Industrial Rayon Corp., W. 98th St. & Walford Ave.
CARSON, John H., The East Ohio Gas Co., 1405 E. Sixth St.
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CLAIBORNE, Tom A., 1440 Union Commerce Bldg.
CONNELLY, D. J., Williams & Co., Inc., 3700 Perkins Ave.
COPLEY, James S., National Carbon Div., Box 6087.
CRAVER, Albert F., The Cleveland Heater Co., 2310 Superior Ave.
DAVIS, L. W., Aluminum Company of America, 2210 Harvard Ave
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DUNASKY, C. F., The Harshaw Chemical Co., 1945 E. 97th St.
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ELLERBRAKE, Earl G., Sohio Pipe Line Co., 1738-A Midland Bldg.
FELDSTEIN, Henry H., Sugar & Chemical Machinery, Inc., 7829 Euclid Ave.
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GOSNELL, Everett C., The Colonial Iron Works Co., 17643 St. Clair Ave.
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PALMERTON

ANDERSON, Edmund Arnold, The New Jersey Zinc Company of Pennsylvania.

PHILADELPHIA

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BLACK, John S., Jr., Metal Weld, Inc., 2617 Hunting Park Ave.
BORST, George E., Chicago Bridge and Iron Co., 1700 Walnut St.
BOSSERT, Earl D., Bell Telephone Co. of Pa., 1401 Arch St.
BRIGGS, W. R., W. A. Briggs Bitumen Co., 3303 Richmond St.
BUEHLER, Martin J. H., American Telephone & Telegraph Co., Bourse Bldg.
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FITHIAN, John W., The Atlantic Ref. Co., 3144 Passyunk Ave.
FLENTJE, Martin E., American Water Works Service Co., Inc., 121 S. Broad St.
GILLIAMS, Francis B., Atlantic Refining Co., 3144 Passyunk Ave.
GODSHALK, James B., Fox Products Co., 4720 N. 18th St.
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HADLEY, Raymond F., Susquehanna Pipe Line Co., 1608 Walnut St.
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HAMILTON, Hugh L., Keystone Pipe Line Co., 260 S. Broad St.
HEISS, Franklin S. D., Bell Telephone Co. of Pa., 1401 Arch St.
HORT, Percy, The Keystone Pipe Line Co., 260 S. Broad.
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ENGLISH, James L., 223 Virginia Rd.
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WISCONSIN

APPLETON

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CUDAHY

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KENOSHA

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MADISON

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MILWAUKEE

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GIFFORD, Edmund W., Himelblau, Byfield & Co., 611 N. Broadway Ave.
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NEENAH

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SOUTH MILWAUKEE

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WAUKESHA

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WEST ALLIS

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WHITEFISH BAY

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WISCONSIN RAPIDS

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WORLAND

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FOREIGN

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BLANCO, Felix F., Independencia 88—Bernal.
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TRINIDAD

RITCHIE, Robert, Trinidad Leaseholds, Ltd., Pointe-A-Pierre.

CANADA

BUCKINGHAM, QUEBEC

SEATH, John, Electric Reduction Co. of Canada Ltd.

CALGARY, ALBERTA

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MOYAR, Robert E., Standard Vacuum Petroleum Maatschappij, Pendopo.

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ABADAN

CLARK, Peter (11604), Angle Iranian Oil Co., Ltd.
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RAS EL MISHAAB

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SOUTH IRAN

ABADAN

ROSS, Kenneth Brebner, Anglo-Iranian Oil Co., Ltd.

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(With Corporate Representatives)

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ALLEGHENY LUDLUM STEEL CORP.
Brackenridge, Pa., W. G. Renshaw

ALLIED CHEMICAL & DYE CORP.
Barrett Div., New York, N. Y., B. C. Cowart

ALLOY STEEL PRODUCTS CO.
Linden, N. J., E. G. Holmberg

ALOX CORP.
Niagara Falls, N. Y., James E. Shields

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New Kensington, Pa., E. D. Verink, Jr.

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Amarillo, Texas, A. F. Cox

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Shreveport, La., L. F. Babcock

ARKANSAS LOUISIANA GAS CO.
Shreveport, La., W. A. Broome

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Belleville, N. J., S. G. Bart

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San Francisco, Cal., J. S. Connell

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Bethlehem, Pa., S. C. Frye

BRANCE-KRACHY CO., INC.
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Bridgeport, Conn., C. L. Bulow

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Philadelphia, Pa., J. D. Farber

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New York, N. Y., A. J. Helmbrecht

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CENTRAL POWER & LIGHT CO.
Corpus Christi, Texas, Wm. M. Mayer

CHAIN BELT COMPANY OF MILWAUKEE
Milwaukee, Wis., R. E. Wicen

CHAMPLIN REFINING CO.
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CHANSLOR-CANFIELD MIDWAY OIL CO.
Los Angeles, Cal., H. L. Briggs

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CHICAGO BRIDGE & IRON CO.
Chicago, Ill., Fred L. Goldsby

CINCINNATI GAS & ELECTRIC CO.
Cincinnati, Ohio, M. J. Pfeiffer

CIT-CON OIL CORP.
Lake Charles, La., Robert L. Hale, Jr.

CITIES SERVICE GAS CO.
Oklahoma City, Okla., Geo. H. Baird

CITIES SERVICE PIPE LINE CO.
Bartlesville, Okla., Harry Nelson

CITIES SERVICE REFINING CORP.
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CLARK BROTHERS CO., INC.
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COLORADO INTERSTATE GAS CO.
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COLUMBIA ENGINEERING CORP.
New York, N. Y., C. F. de May

COLUMBUS & SOUTHERN OHIO ELECTRIC CO.
Columbus, Ohio, F. H. Streit

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Terre Haute, Ind., Richard S. Egly

COMMONWEALTH EDISON CO.
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CONSOLIDATED EDISON CO. OF NEW YORK, INC.
New York, N. Y., L. J. Gorman

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*The revised Articles of Organization which became effective January 1, 1950, incorporates the grades of membership formerly designated as "Associate" and "Corporate," into one grade of membership designated as "Corporate".

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Granite City, Ill., G. A. Holtzscher, Jr.

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Neenah, Wis., J. T. Whelan

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Westfield, N. J., W. F. Fair, Jr.

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St. Louis, Mo., C. E. Schoene

LEBANON STEEL FOUNDRY
Lebanon, Pa., E. H. Platz, Jr.

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El Dorado, Ark., J. B. Rogerson

LONE STAR GAS CO.
Dallas, Texas, J. L. Foster

LOUISIANA POWER & LIGHT CO.
New Orleans, La., W. T. Hess

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MAGNOLIA PIPE LINE CO.
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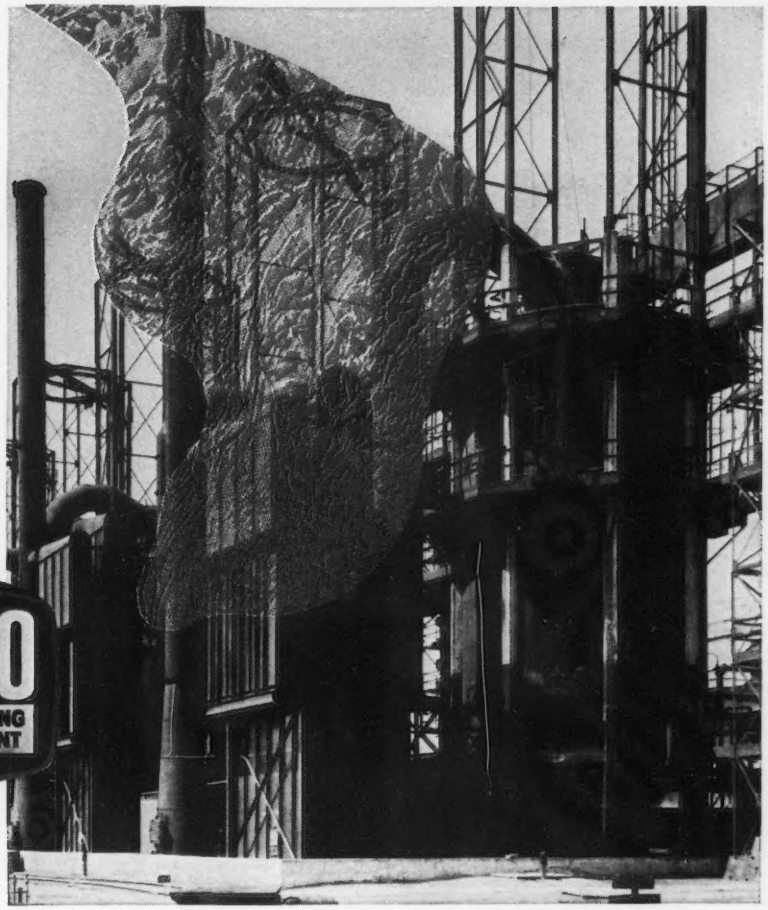

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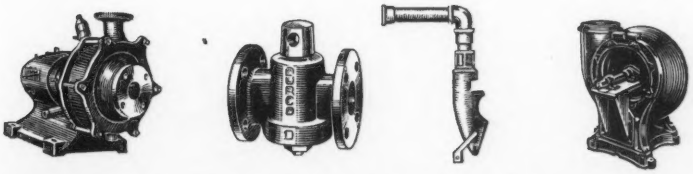

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